AFML-TR-65-20

THE MODIFICATION OF AN INFORMATION RETRIEVAL SYSTEM BY IMPROVING VOCABULARY CONTROL, INDEXING CONSISTENCY AND SEARCH CAPABILITIES

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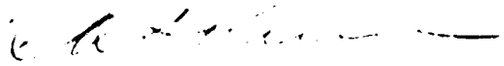
FOREWORD

This report was prepared by the University of Dayton Research Institute under Air Force Contract AF 33(615)-1132. The work described herein was accomplished under Project No. 7381 and Task No. 738103. This effort was administered under the direction of the Materials Information Branch, Materials Applications Division, Air Force Materials Laboratory with H. B. Thompson, MAAM, as project engineer.

This is a summary technical report and covers the work accomplished from 1 December 1963 through 30 November 1964.

The author acknowledges the efforts of his staff in the work they accomplished during the past year in establishing the needed vocabulary controls for the system and their authoring the appendices to this report.

This Technical Documentary Report has been reviewed and is approved.



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ABSTRACT

This report covers the activities of the Technical Information Center of the University of Dayton Research Institute for the period 1 December 1963 through 30 November 1964. In particular, this report describes the need for and establishment of vocabulary controls for a coordinate indexing retrieval system involving multidisciplinary terminology. Included in the controls is an improved fragmentation system for the handling of organic compounds. The elimination of role indicators from the indexing procedures is also briefly discussed. The system that is described was established to handle the scientific and technical documents that are on file in the library facility of the Air Force Materials Laboratory. Approximately 16,000 documents have been indexed and the revised thesaurus contains slightly over 10,000 terms.

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I. INTRODUCTION

The Air Force Materials Laboratory (AFML), through its Materials Information Branch, sponsors, supports, or controls the activities of seven specialized information and data centers which are located throughout the country. The University of Dayton Research Institute established one of these centers. A document retrieval system has been established to handle an extensive collection of scientific and technical reports that pertain to all phases of materials research of interest to the Air Force. The establishment of the system was described in detail in a previous report, RTD-TDR-63-4263 (AD 428 423).

This report describes work accomplished from December 1963 to December 1964 and pertains primarily to the changes made in the established system in order to make it more compatible to future growth. To better understand the need for the changes, the aforementioned report is summarized below.

The system established by the University is a coordinate indexing system utilizing a NCR 304 computer for the processing of the data. The use of a computer was particularly desirable because tools needed for manual searching of the system could be generated and the computer could also be used for machine searching, particularly for the processing of multiple searches. It was also realized that the computer would be needed more frequently as the system grew.

The use of deep indexing with links and roles formulated the basis of this system. The role indicators used were a slightly modified version of those used by the Du Pont Company. The first five hundred documents that were indexed averaged over eighty link-role-term combinations per report. As the information analysts gained experience, the average number of entries per document was reduced to slightly over forty. The elimination of roles from the system, the purpose of which is explained in greater detail in the next section of this report, reduced the average to about twenty-seven entries per document.

The decision to let the system's vocabulary be generated through the indexing process was also basic in the system's design. An essential part of that decision was for the information analysts to use very specific terms in the naming of materials. The editing of the terms generated by the indexing of approximately 6,000 documents resulted in a vocabulary of slightly over 18,000 terms. By December 1963, the system was established and operable, the indexed library contained about 10,000 documents, and a thesaurus of over 18,000 multidisciplinary terms had been generated.

The two aspects of this system that were evaluated and changed during the past year were the use of roles in indexing and vocabulary control. These items are discussed in detail in the next two sections of this report.

II. ELIMINATION OF ROLE INDICATORS

The primary purpose of using role indicators is to decrease the number of irrelevant documents retrieved in response to a search question. The University of Dayton's experience with the use of roles showed that their use also prevented the retrieval of relevant information unless all possible roles were used in every search and when this was done, the retrieval of irrelevant information increased. The primary problem encountered with the use of roles in the system established for AFML was the inability to assign unambiguous definitions to the role indicators because of the multidisciplinary nature of the material contained in the system. Even within a single discipline, the use of roles requires either redundant indexing by assigning all possible role indicators to each term or redundant searching by the same method. This is particularly true when a user wants all, rather than some, information in a particular file collection pertaining to his question.

The procedure followed in the indexing process when role indicators are used is as follows: 1) the information analyst first examines a document to determine its important concepts, 2) each concept is then put into the form of a statement, 3) the key terms of the statement are selected, and 4) role indicators are applied to the terms according to the structure of the statement. As an example, consider the following statement which is typical of statements that could be formulated from many documents contained in the AFML library:

Statement A

> A primary topic of consideration is the effect of temperatures -350° to -100°F on the strength, ductility and tensile elastic constants of Aluminum 2024, Aluminum 6061 and Aluminum 7075 to be used for rocket fabrication.

Role 9 was used in this system to specify a dependent variable or a process or property being affected. According to those definitions, the mechanical properties (strength, ductility and tensile elastic constants) listed in the aforementioned statement would each be assigned the 9 role. Consider now the following two statements:

Statement B

> A primary topic of consideration is the strength, ductility and tensile elastic constants of Aluminum 2024, Aluminum 6061 and Aluminum 7075 at temperatures -350° to -100°F for consideration as fabrication materials in rockets.

Statement C

A primary topic of consideration is the evaluation of Aluminum 2024, Aluminum 6061, and Aluminum 7075 for use in rocket fabrication using strength, ductility and tensile electric constants at temperatures -350° to -100° F as evaluation parameters.

Statements B and C are essentially equivalent ways of expressing the same information that is contained in Statement A. However, according to definitions of the roles used in this system, the mechanical properties would be assigned the 8 role in Statement B and 1 role in Statement C. The same problem exists in assigning role indicators to the other key terms of the three statements. An information analyst may or may not assign all possible role indicators to each key term of a statement. A search specialist cannot assume that this has been done and, therefore, he must search under all possible roles.

An evaluation of links and roles used in the retrieval of information from this system was made by Lt. Col. J. D. Sinnett, USAF, as his thesis study for the Air Force Institute of Technology. The results of his study are reported in the AFML Report ML-TDR-64-152 (AD 432 198). One item was of particular interest to this organization. A total of twenty-four questions were used in the evaluation study. Eighty-nine key terms were chosen as the basis of those questions and, through the use of the system's thesaurus, the total number of terms used in the searches was increased to 428 by the use of logical sums (OR terms). The redundancy required when searching a file using role indicators can be seen from the fact that a total of 1500 terms (term-role combinations) were required to perform the 24 searches when they were used in the searching process. The fact that searches made using links but not roles gave the best overall results was not surprising to the persons who had established the system. Although the value of roles was questioned, a decision was made to continue their use until the system became operable and could be evaluated through testing procedures. The only adverse effect of that decision was the addition of a small amount of "noise" to the system through the use of adjectives and "indexing" terms that had to be added to formulate the statements in the indexing process. Through the more recent use of bound terms, a large percent of that "noise" has been eliminated.

III. VOCABULARY CONTROL

The generation of a vocabulary of 18,000 terms appeared to be quite reasonable in light of the multidisciplinary nature of AFML's file collection. However, when the posting index tape was updated in December 1963, over 30,000 terms were rejected by the computer. It is estimated that about 95 percent of the rejected terms were new organic compounds, alloys and trade-named materials that had been generated through the indexing of an additional 4,000 documents. Since the documents that were indexed dealt with research and development of materials, the generation of new terms was anticipated but the quantity far exceeded the expectations. It was obvious that steps had to be taken toward vocabulary control in order to maintain a manual searching capability and to maintain a "reasonable" vocabulary even for computer searches, regardless of the number of documents contained in the system. It was also obvious that the area requiring control was the naming of materials and trade names.

The approach taken to establish a vocabulary control was to divide the vocabulary into classes of materials for analysis. The purpose of each analysis was to determine the possibility of generalizing the naming of materials without losing an undue amount of specificity. The area requiring the most analysis was in the handling of organic compounds and metallurgical terms, especially in the naming of alloys and trade names. The other materials that were analyzed individually included ceramics, cermets, composites, elastomers, industrial chemicals (fibers, fuels, lubricants, oils, paints, propellants and specialty chemicals), polymers and metal systems. Each analysis involved consideration of the following four points: 1) compatibility of terminology between areas, 2) effect of terminology on indexing and indexer qualifications, 3) effect of terminology on searching, especially from the user's standpoint, and 4) the amount of specificity that could be retained and yet have the vocabulary reach a semi-permanent plateau so that each document indexed would not create new terms.

The areas of organic compounds and metallurgical terms were the first to be analyzed. The problem existing in the naming of organic compounds can best be explained by listing here several Silanes as they appeared in the original vocabulary:

Silane, Didodecyl
Silane, Didodecyldihexyl
Silane, Didodecyldioctyl
Silane, Didodecyldiphenyl
Silane, Diethoxydimethyl
Silane, Diethoxydiphenyl
Silane, Diethoxymethylphenyl
Silane, Diethoxyvinyl

There were, in fact, 195 Silanes which were part of an organic compound vocabulary of 18,000 specific terms in the system (this number includes those terms that were rejected by the computer at the time when the posting index was updated). The two possible approaches to solving this problem were the use of a coded system or of a fragmentation system. The use of a coded system was not feasible since the terminology would not be compatible with the other areas and manual searching would surely have to be eliminated. A fragmentation system, employing essentially unit terms, was then considered as the only alternative. The only undesirable attribute of such a system that could be foreseen was the possibility of numerous false retrievals. A University Information Specialist developed a special system which is now used to handle the naming of organic compounds. This is essentially a fragmentation system but it utilizes "connectors" to show the relationship between basic structures and substituent groups. The system is described in detail in Appendix I to this report.

The problems existing in the handling of metallurgical terminology were not as monumental as that of organic compounds but were similar in nature, particularly in the naming of alloys. As an example, the following are only a few of the titanium alloys as they appeared in the original vocabulary:

Titanium - 6 Al - 0.5C - 34V
Titanium - 6 Al - 0.5C - 39V
Titanium - 6 Al - 1C - 38V
Titanium - 7 Al - 0.5C - 43V
Titanium - 7 Al - 1.5C - 42V
Titanium - 2 Al - 5 Cr
Titanium - 3 Al - 5 Cr
Titanium - 3 Al - 6 Cr

There were, in fact, close to 500 specific titanium alloys that had been generated through the indexing process and there was no reason to believe that another 500 alloys would not be generated through additional indexing. A fragmentation system of any type was determined to be unacceptable because of the large number of postings that could appear under many of the terms. By eliminating the percentages and listing the alloying agents alphabetically, the number of titanium alloys was reduced to 138. The University of Dayton was fortunate to have performed a number of searches involving metallic materials and was able to consider user's requirements to a certain extent in its decisions. Basically, it was determined that metallurgical terminology could be generalized to some extent without causing any measurable increase in false retrievals. The present handling of metallurgical terminology including materials, processes, properties and products, is explained in detail in Appendix II.

The changes made in the areas of organic chemistry and metallurgy would have been sufficient at the present to give the system a reasonable

vocabulary. However, there were many other materials in the system that, although not considered problems at this time, could cause a great deal of difficulty in the near future; polymers and ceramics are perhaps the best examples of these. As the investigations proceeded into these other areas, difficulties were in fact discovered. These difficulties were found to exist in the indexed nomenclature of the materials. The primary cause of the difficulties was the fact that a limited number of personnel indexed documents representing many disciplines and the author's terminology was accepted and used in those specific areas unfamiliar to the indexers. In solving this problem, experts in the various areas were contacted in order to get a better understanding of the choice and use of terminology in those areas. Conferences of this type were found to be very beneficial to both parties involved; the University learned what to put into the system and the persons contacted, who were potential users of the system, learned what the system could do for them.

The vocabulary control discussions of the remaining areas are presented in Appendices III and IV. The following materials are treated in Appendix III; oils, lubricants, hydraulic fluids, fuels, propellants, polymers, elastomers, paints, varnishes, strippable coatings, primers, sealants, fibers, specialty chemicals and inorganic nomenclature. Appendix IV covers the areas of ceramics, cermets, cemented carbides, composites, laminates, systems, eutectics and physics.

The appendices to this report serve two purposes: 1) the control of terminology in specific areas is discussed, and 2) they are written in a manner suitable for use as indexing ground rules. Some general comments on indexing ground rules appear in the next section of this report. The efforts expended on the vocabulary control program show very satisfactory results: the vocabulary of over 48,000 terms was reduced to about 10,000 terms without affecting search capabilities and results to any great extent and the rate of addition of new terms to the vocabulary has been minimized.

IV. INDEXING GROUND RULES

The elimination of role indicators simplified the indexing procedures and reduced the number of indexing ground rules. As can be seen in the appendices, specific indexing techniques are primarily concerned with terminology or vocabulary control while the basic indexing procedures remain unchanged. First, the information analyst must become familiar with the contents of a document before he can determine its important concepts. For the majority of documents, this can be accomplished by reading the abstract and conclusions, and by scanning the table of contents and the body of the report. The key terms are then chosen that best describe the report's contents and links are used to maintain separation of the terms of principal concepts. The use of links has become valuable in separating organic compounds and preventing the "connection" of substituent groups to the wrong basic structure. Any indexed terms that are not already included in the system's vocabulary are recorded on master word cards. These cards are reviewed once a week by all staff members. This method permits the revising of the vocabulary tape prior to the updating of the posting index and at that time only key punching errors should be rejected by the computer.

Another major change made in the indexing procedure involved the indexing of progress reports. When a progress report is received in the AFML library, a check is made in a cross-referenced card file to see if a previous report on the same contract is already in the file. If there is, the document is assigned the same accession number and filed. If the report is the first to be received on the contract, it is assigned a new accession number and processed for indexing. In analyzing a progress report, the specific details of that report are not indexed but the information analyst attempts to extract the overall concept of the contractual effort. The final report on the contract is indexed in order to supplement the information obtained from the first progress report received. Because of this method of handling progress reports, the exact size of the system is actually unmeasurable. Slightly less than 16,000 documents have been indexed but the file collection may contain as many as 25,000 documents.

The changes made in the system's vocabulary made it advisable to make one other change in the indexing procedure. Realizing the possibility that users might ask for information on specific materials, a decision was made to use more scope notes on the index cards in order to simplify the screening of search results. Any notes that an information analyst thinks would be beneficial in the screening process are written on the index card in script and enclosed in parentheses. These notes are not key punched and, therefore, do not affect the computer programs. Specific use of these scope notes is described in more detail in the appendices.

V. SUMMARY AND DISCUSSION

The University of Dayton Research Institute has established what it refers to as a dynamic information retrieval system for the Materials Information Branch, Materials Applications Division, Air Force Materials Laboratory. During the past year, the system underwent two major changes; the elimination of role indicators and the establishment of vocabulary controls. There are undoubtedly systems in existence for which role indicators will serve the purpose for which they are designed. However, as experienced in this system, if redundant indexing and/or redundant searching is required to assure the retrieval of all possible pertinent information, the value of the use of roles for that system should be questioned.

The development of the basic structure-substituent-connector concept for the handling of organic compounds should prove beneficial to many organizations. This system enables the retrieval of very specific as well as general classes of compounds and is capable of handling many thousands of compounds with a relatively small vocabulary. The experience of the University of Dayton in the area of vocabulary control suggests that more emphasis on the choice of terminology and degree of specificity should be a major consideration in the basic design of a system. The basic design of this system was such that any changes made would not require the reindexing of documents. As an example of this, the use of role indicators required the splitting of many terms in the system. When the role indicators were eliminated, the split terms were rebound through computer searches. Even the fragmentation of the 18,000 compounds was accomplished without the reindexing of documents. In order to correct misused terms, many documents had to be "seen" but not reindexed.

As far as search activity is concerned, the University performed an average of three searches per week during the past year. This is no indication, however, of the total number searches made of the system since copies of the thesaurus and posting index had been widely distributed throughout the Air Force Materials Laboratory for personal use by scientists and engineers. The possibility that the system would be used more frequently if it were divided into sub-systems is now being investigated. The results of this investigation will also be used for determining the feasibility of a microfilm system for the storage and retrieval of information in place of a computer system.

It is not known how many searches must be made in order to justify an information retrieval system; if indeed the justification for a system could be based on the number of searches made. However, it is felt that this system should be used much more than it has been in the past. A possible explanation for the lack of use could be the fact that between 80 to 90 percent of the documents now in the files have been generated internally or by contractors to AFML and copies of those documents are on file in areas other than the library. A proposed change in the acquisition policy wherein more information will be sought from other DOD agencies, NASA and AEC should generate more use of this system in the future.

APPENDIX I

A FRAGMENTATION SYSTEM FOR HANDLING ORGANIC COMPOUNDS

By
P. Kokoropoulos

INTRODUCTION

The fragmentation system described is based on the concept that each organic compound consists of a number of discrete fragments connected in a given order. Since many compounds can be constructed from the same fragments by changing the order in which they are connected, a relatively small number of fragments is sufficient to describe a large number of compounds.

The fragments of an organic compound can be either complete compounds which are referred to as "Basic Structures" or atoms, and functional groups or radicals called "Substituents." The fragments are named according to the IUPAC Systematic Nomenclature with few exceptions where common (trivial) names are used.

The vocabulary of the present system consists of fragments as described with a slight modification; each fragment is assigned a two consecutive digit number called a "U. D. Connector" which specifies the fragment as a basic structure or indicates the position of the fragment as a substituent group in a structure.(1)

BASIC STRUCTURES

According to the IUPAC Systematic Nomenclature, each organic compound is named after a basic structure and one or more substituents, i.e., nitrobenzene, ethylpropylamine and amino-acetic acid. In most cases the basic structures are either simple compounds, hydrocarbons (aliphatic and aromatic), alcohols, aldehydes, acids, simple heterocyclic compounds, or a functional group, such as amine, ketone, or sulfone; i.e., chlorotoluene, phenylpropylketone, aminophenol. In some cases common (trivial) names are used as basic structures. Common names are retained (1) when they are widely used (Aniline, acetone, phenol, toluene, acetic acid), and (2) when fragmentation into simpler systematic terms would create a very large number of postings on a given term. Thus the terms aniline, phenol and toluene are used instead of benzene/amino, benzene/hydroxy and benzene/methyl. However, alpha-substituted toluenes are fragmented.

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(1) P. Kokoropoulos and F. Scheffler, "The Basic Structure-Substituent-Connector Concept for Handling Organic Compounds for Information Retrieval Purposes," Proceedings, ADI, 1964, Annual Meeting

The selection of the basic structure of an organic compound is dictated by its systematic name; i.e., 4-ethyl-2-methyl pyridine, butyl methyl ketone, fluorobenzene. When functional groups are present in a molecule, the one highest in the order of precedence determines the basic structure; i.e., o-aminobenzoic acid, N,N-diethylaminobenzaldehyde. The order of precedence of functions given by Chemical Abstracts (CA vol.56 p. 12N) is followed.

THE U.D. CONNECTORS

The U.D. Connectors are sets of two consecutive digits which indicate the "connection" of a substituent with a basic structure or another substituent. All basic structures have the connector 11, while unsubstituted compounds are designated with the connector 10. Thus acetic acid 11 indicates that one or more hydrogens have been replaced by other groups. A substituent on a basic structure is designated by the connector 12. Further substitution is indicated by connectors 23, 34, 45, etc. Examples of fragmentation using connectors are given in Figure 1.

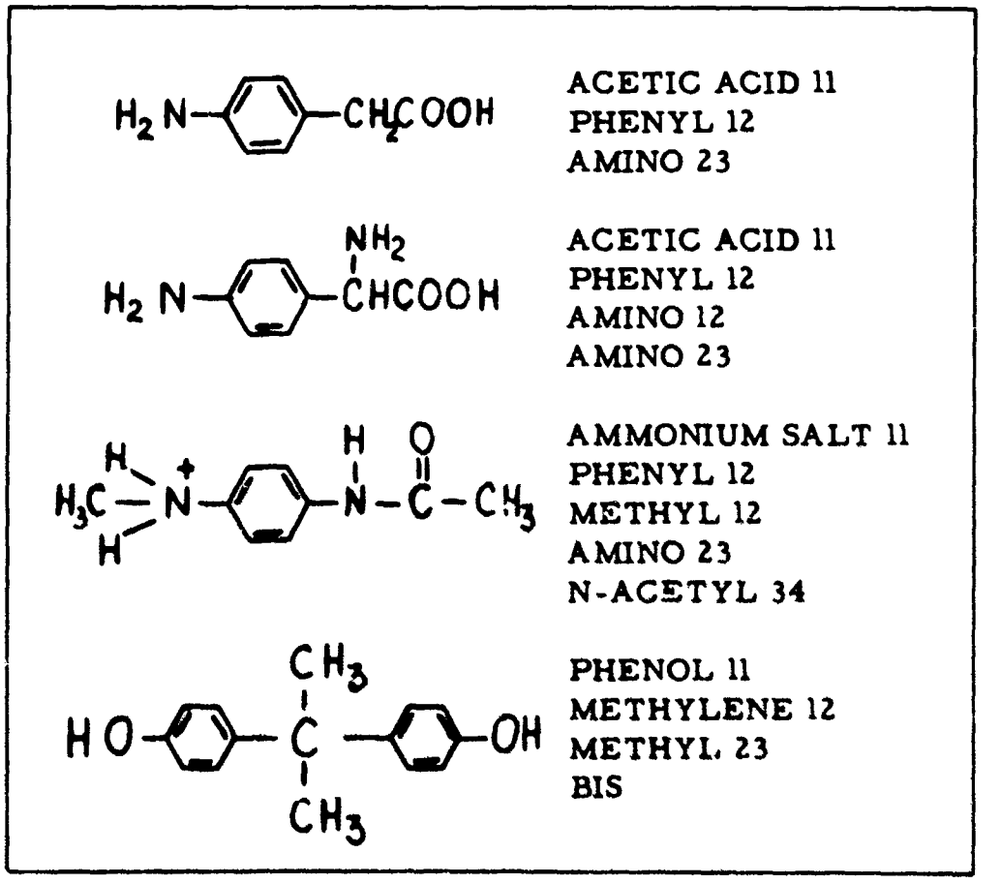


Figure 1. Fragmentation of Organic Compounds Using Connectors

The use of connectors enables the searcher to search either for one specific compound or for a class of compounds. For example, searching under the terms AMINE P 11, AMINE S 11, AMINE T 11, AMINO 12, AMINO 23, etc., will yield all information available on amines. On the other hand, searching under AMINE P 11/PROPYL 12 will yield all information available on primary Propylamine. Thus the desirable degree of generality or specificity in searching is achieved when the connectors are used.

LINKS

Links are used in order to correlate materials with properties or processes and in order to distinguish the fragments of various compounds in a given document. An example is given in Figure 2.

Polarographic Reduction of Polynuclear Aromatics

ABSTRACT

Polarographic reduction potentials (E 1/2) have been measured for polynuclear aromatic hydrocarbons. The E 1/2 parameters for structurally similar hydrocarbons have been related to the positions of the respective long wavelength "p" bands. Polarographic reduction potentials have also been determined for a series of substituted pyrenes and anthracenes. E 1/2 is shown to relate to the electronic effect of the substituent group. The application of polarography to the characterization of aromatics in complex pyrolytic residues is discussed.

LINK		TERM
A	B	POLAROGRAPHY
A		IONIZATION POTENTIAL
A		ANTHRACENE 11
A		NAPHTHALENE 10
	B	ARENE 11
A		ARENE 10
A	B	AMINO 12
A		PHENYL 12
A	B	METHYL 12
A		ANTHRACENE 10
A		BENZYL 12
A	B	N-ACETYL 23
A		BROMO 12
A	B	CHLORO 12
A	B	NITRO 12
A	B	HALF WAVE POTENTIAL

Figure 2. Index Entries of a Technical Report Showing Use of Links and Connectors

1. HYDROCARBONS

1.1 ALIPHATIC HYDROCARBONS. Aliphatic hydrocarbons, saturated or unsaturated, unbranched chains with 1 to 10 carbon atoms retain their names. Branched hydrocarbons are named after the longest chain. Hydrocarbons with straight chains of 11 or more carbon atoms are called ALKANE, ALKENE, ALKADIENE, ALKYNE,etc. Common names retained: ETHYLENE ($CH_2=CH_2$), ALLENE ($CH_2=C=CH_2$) and ACETYLENE (CH=CH).

1.2 RADICALS OF ALIPHATIC HYDROCARBONS

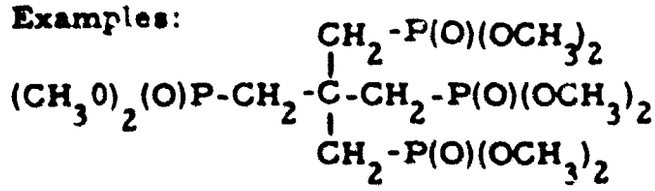
1.2.1 The term ALKYL indicates univalent radical of a saturated hydrocarbon, except: a) radicals with total number of carbon atoms 1-4 branched or unbranched which are called METHYL, ETHYL, PROPYL, BUTYL b) the radical ETHYLHEXYL.

1.2.2 The term ALKENYL indicates univalent radical of unsaturated hydrocarbon except: the radicals ETHYNYL (CH=C-), PROPENYL (CH_3-CH=CH-), ALLYL (CH_2=CH-CH_2-), VINYL (CH_2=CH-), and BUTENYL.

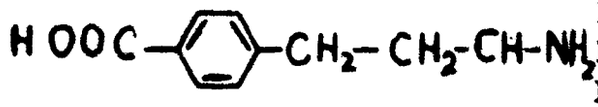
1.2.3 Saturated bivalent radicals used in the system are ETHYLIDENE (CH_3-CH=), ETHYLENE (-CH_2-CH_2-), TRIMETHYLENE (-(CH_2)3-), POLYMETHYLENE (-(CH_2)), ALKENYLENE, also the unsaturated bivalent VINYLIDENE CH_2=C=.

1.2.4 Trivalent and higher radicals are named from the corresponding hydrocarbons or univalent radicals.

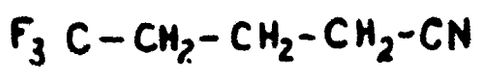
Examples:



PHOSPHONATE 11
METHYL 12
ALKYL 12
TETRAKIS



BENZOIC ACID 11
PROPYL 12
IMINO 23

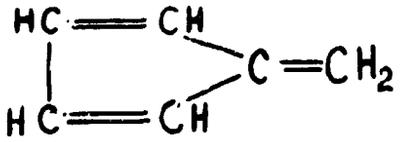


BUTANE 11
FLUORO 12
CYANO 12

1.3 CYCLIC HYDROCARBONS

1.3.1 ALICYCLIC HYDROCARBONS. Prefix CYCLO-. Nomenclature follows the same rules as in aliphatic hydrocarbons, i.e., CYCLOHEXANE, CYCLOOCTANE, CYCLOALKANE etc.

EXCEPTION: FULVENE (methylenecyclopentadiene)



1.3.2 RADICALS OF ALICYCLIC HYDROCARBONS. Saturated radicals: CYCLOALKYL, unsaturated radicals: CYCLOALKENYL. EXCEPTIONS: CYCLOPROPYL, CYCLOPROPENYL, CYCLOBUTYL, CYCLOBUTENYL, CYCLOPENTYL, CYCLOPENTENYL, CYCLOPENTADIENYL, CYCLOHEXYL, CYCLOHEXENYL, CYCLOHEXADIENYL.

1.3.3 BRIDGED HYDROCARBONS. Prefix BICYCLO- The same rules as in aliphatic and alicyclic hydrocarbons are followed.

1.3.4 AROMATIC HYDROCARBONS. All aromatic hydrocarbons are grouped under the general name ARENE except: BENZENE, NAPHTHALENE, TOLUENE, PHENANTHRENE, XYLENE, ANTHRACENE, BIPHENYL, BINAPHTHYL, TERPHENYL, BICYCLOHEXYL, POLYPHENYL, TERCYCLOHEXYL.

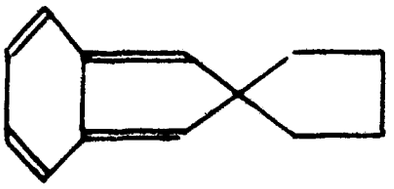
1.3.5 RADICALS OF AROMATIC HYDROCARBONS. Monovalent Radicals: ARYL, Bivalent Radicals: ARYLENE and ARYLIDENE. EXCEPTIONS: PHENYL, PHENYLENE, TOLYL, BENZYLIDENE, NAPHTHYL, BENZYL.

1.3.6 SPIRO COMPOUNDS. In naming spiro compounds the same rules as in all hydrocarbons are followed. Total number of carbon atoms is considered, with the prefix spiro:

e.g.

SPIRODECANE

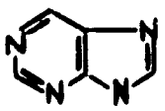
More complicated structures are named from both parts and the term spiro, e.g.,



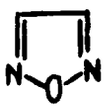
INDENE-CYCLOPENTANE 10, SPIRO

1.4 HETEROCYCLIC COMPOUNDS

1.4.1 Heterocyclic compounds containing Nitrogen, Oxygen, or Sulfur are generally named from the heteroatom(s) they contain, i.e.



NITROGEN HETEROCYCLE



NITROGEN-OXYGEN HETEROCYCLE

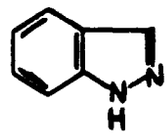
exceptions are listed in Table 1.

TABLE 1

BASIC STRUCTURE	RADICALS
THIOPHENE	THIENYL
FURAN	FURYL
PYRAN	PYRANYL
XANTHENE	XANTHENYL
PYRROLE	PYRPOLYL
IMIDAZOLE	IMIDAZOLYL
PYRAZOLE	PYRAZOLYL
PYRIDINE	PYRIDYL
PYRAZINE	PYRAZYL
PYRIMIDINE	PYRIMIDYL
PYRIDAZINE	PYRIDAZYL
INDOLE	INDOLYL
QUINOLINE	QUINOLYL
ISOTHIAZOLE	ISOTHIAZOLYL
PYRROLIDINE	PYRROLIDYL
IMIDAZOLIDINE	IMIDAZOLIDYL
PYRAZOLIDINE	PYRAZOLIDYL
PIPERIDINE	PIPERIDYL
PIPERAZINE	PIPERAZINYL
MORPHOLINE	MORPHOLINO
ISOXAZOLE	ISOXAZOLYL
OXATHIIN	HETERYL
ARSAZIN	HETERYL
THIAZINE	HETERYL
OXAZINE	HETERYL
ACRIDINE	HETERYL

Heterocyclic compounds when used as basic structures containing fused benzene rings are fragmented into the heterocyclic part and the term

BENZO 12

i.e.  PYRAZOLE 11
BENZO 12

Partially hydrogenated compounds are named from the unsaturated compound and the term Hydro 12

e.g.  PYRAZOLE 11
HYDRO 12

1.4.2 RADICALS OF HETEROCYCLIC COMPOUNDS

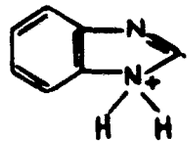
Radicals of heterocyclic compounds are called HETERYL

EXCEPTIONS are listed in Table 1.

Radicals of compounds containing fused benzene rings and Radicals of partially hydrogenated compounds are called HETERYL.

1.4.3 "ONIUM" SALTS OF HETEROCYCLIC COMPOUNDS

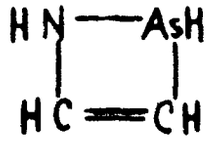
Names of "Onium" salts of heterocyclic compounds are formed from the compound and the term salt

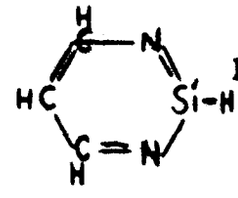
 IMIDAZOLE SALT 11
BENZO 12

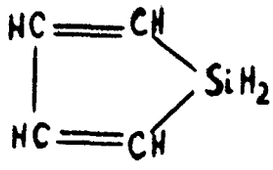
 PYRIDINE SALT 11

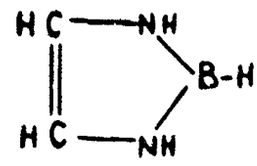
1.4.4 Monocyclic compounds containing one or more heteroatoms are named according to the Hantzsch-Widman System (J.A.C.S. 80, 5566, (1960)).

Examples:

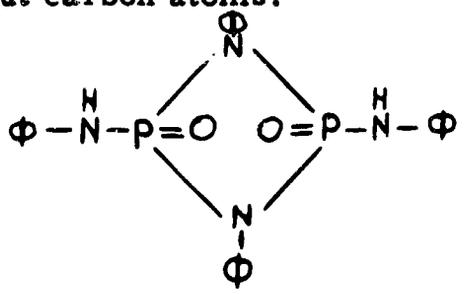
 AZARSETINE

 DIAZASILINE

 SILOLE

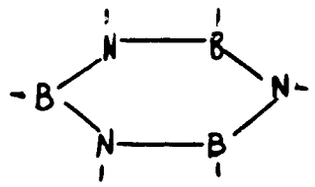
 DIAZABOROLE

1.4.5 The Hantzsch-Widman System is extended to cyclic systems without carbon atoms.

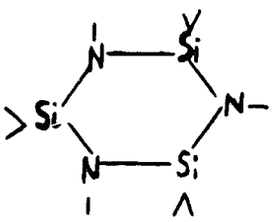


DIAZAPHOSPHETIDINE 11
OXO 12
AMINO 12
PHENYL 12
N-PHENYL 23
BIS

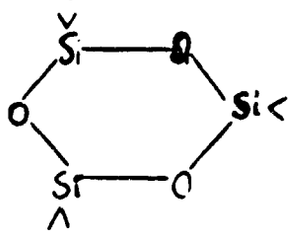
and the more familiar names



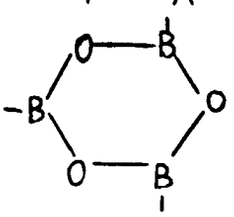
BORAZINE



SILAZINE



SILOXINE



BOROXINE

2. ACIDS

2.1 CARBOXYLIC ACIDS

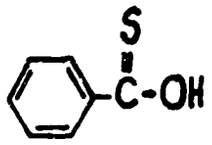
2.1.1 Names of carboxylic acids are formed from the hydrocarbons and the endings -oic acid, -dioic acid. When 3 or more carboxyl groups are present the names are formed from the hydrocarbon and the terms tricarboxylic acid, tetracarboxylic acid,etc. The same rules of nomenclature used in hydrocarbons are followed. The following common names are retained:

FORMIC ACID	OXALIC ACID
ACETIC ACID	STEARIC ACID
ACRYLIC ACID	MALONIC ACID
METHACRYLIC ACID	MALEIC ACID
CITRIC ACID	FUMARIC ACID
PALMITIC ACID	BENZOIC ACID
OLEIC ACID	TARTARIC ACID

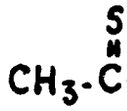
2.1.2 Acids of Cyclic Compounds: Alicyclic, Aromatic and Heterocyclic are named from the compound and the terms Carboxylic Acid, dicarboxylic Acid, i.e. CYCLOHEXANECARBOXYLIC ACID, NAPHTHALENE

DICARBOXYLIC ACID, PYRIDINECARBOXYLIC ACID, exceptions: PHTHALIC ACID, ISOPHTHALIC ACID, TEREPHTHALIC ACID.

2.1.3 For sulfur and selenium substituted carboxyl groups the prefixes thio, dithio, seleno and diseleno are used.



THIOBENZOIC ACID



DITHIOACETIC ACID

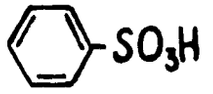
2.2 ACIDS OTHER THAN CARBOXYLIC
(Always with connector 11 when used as basic structures)

2.2.1 Sulfonic Acid
Sulfinic Acid

2.2.2 Phosphonic Acid
Phosphinic Acid
Phosphonous Acid
Phosphinous Acid

2.2.3 Boronic Acid
Borinic Acid

2.2.4 Arsonic Acid



SULFONIC ACID 11
PHENYL 12

2.3 ACID DERIVATIVES

2.3.1 Acid Halides

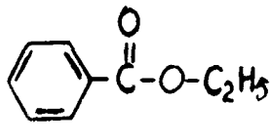
Acid halides retain their names. The nomenclature follows the rules and exceptions used in acids, i.e., ACETYL CHLORIDE, BUTANOYL CHLORIDE, PYRIDINECARBOXYL CHLORIDE, DECANEDIOYL FLUORIDE, SULFONYL FLUORIDE.

2.3.2 SALTS

Salts are named from the acid radical and the term salt (always with connector 11). Same rules as in acids are followed.

i.e. CH_3COONa ACETATE SALT 11

2.3.3 ESTERS. Esters are named from the acid radical, the alkyl radical and the general non posting term ESTERS (used always without connector).

i.e.  BENZOATE 11
ETHYL 12
ESTERS

2.3.4 ACID ANHYDRIDES

Acid anhydrides retain their names. The nomenclature used in acids is followed.

i.e. ACETIC ANHYDRIDE, BENZOIC ANHYDRIDE, PYRIDINE-CARBOXYLIC ANHYDRIDE.

2.3.5 AMIDES

The names of the amides are formed from the names of the hydrocarbons by dropping the final "e" and adding "amide"; PROPANAMIDE, HEXANAMIDE, ALKANAMIDE. Common names retained are: FORMAMIDE, ACETAMIDE, ACRYLAMIDE, BENZAMIDE, PHTHALAMIDE, MALEAMIDE, MALONAMIDE, OXAMIDE.

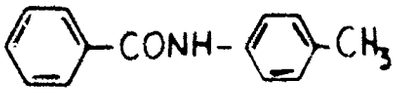
Names of amides of alicyclic, aromatic and heterocyclic compounds are formed from the name of the compound and the term carboamide, i.e. NAPHTHALENE-CARBOXAMIDE, CYCLOHEXANECARBOXAMIDE, PYRIDINECARBOXAMIDE.

Sulfur substituted amides. The prefix "thio" is added to the amide: THIOFORMAMIDE, THIOPROPANAMIDE, THIOXAMIDE, NAPHTHALENE-THIOCARBOXAMIDE.

The same rules are followed in naming diamides, dithioamides, dicarbonamides and dithiocarboxamides.

N-Substituted amides are so designated

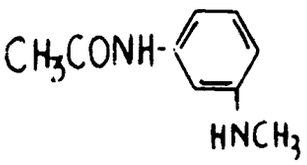
$CH_3CONH\text{-}C_6H_5$ ACETAMIDE 11/N-PHENYL 12

 BENZAMIDE 11/N-TOLYL 12

Diacyl and triacyl derivatives of ammonia are named as N-substituted amides.

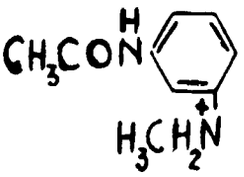
i.e. Diacetamide $(CH_3CO)_2NH$ ACETAMIDE 11/N-ACETYL 12
Tribenzamide $(C_6H_5CO)_3N$ BENZAMIDE 11/N-BENZOYL 12

The order of precedence of functions is followed thus:



ACETAMIDE 11
N-PHENYL 12
AMINO 23
METHYL 34

but



AMMONIUM SALT 11
METHYL 12
PHENYL 12
AMINO 23
N-ACETYL 34

The same rules are followed in naming amides of acids other than carboxylic: SULFONAMIDE 11, PHOSPHONAMIDE 11, etc.

Exceptions: Amides of Boronic and Borinic acids are named BORANE 11/ AMINO 12

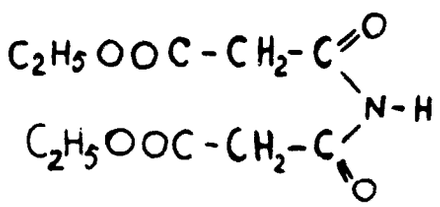
2.3.6 AMIDINES

Nomenclature follows the same rules as in amides.

2.3.7 IMIDES

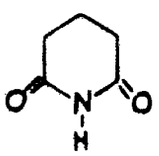
Nomenclature follows the same rules as in amides. In the presence of functions higher in the order of precedence the term IMIDO 12 is used.

PROPANOATE 11
IMIDO 12
ETHYL 12
BIS



Exceptions: The following common names are retained: MALEIMIDE, PHTHALIMIDE, MALONIMIDE.

Imides can be named from the heterocycle and the term KETO 12



PIPERIDINE 11/KETO 12

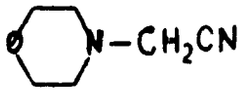
2.3.8 NITRILES

Nitriles are named from the hydrocarbon and the term CYANO 12. The rules of the hydrocarbon nomenclature are followed.

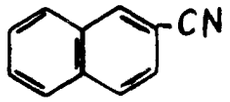
Common names retained ACETONITRILE and BENZONITRILE. (Note the expression BENZENE 11/ CYANO 12 indicates 2 two or more -CN groups attached to the Benzene ring).

Examples:

$CH_3CH_2CH_2CN$ PROPANE 11/CYANO 12



ACETONITRILE 11/MORPHOLINO 12

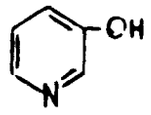


NAPHTHALENE 11/CYANO 12

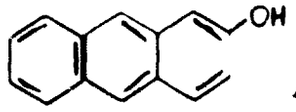
3. ALCOHOLS, PHENOLS AND OTHER HYDROXY COMPOUNDS

3.1 Alcohols are named from the hydrocarbons and the endings ol, diol etc. The total number of carbon atoms is considered e.g. METHANOL, NONANOL, CYCLOHEXANOL, ALKANOL. Exceptions: ALLYL ALCOHOL, METHALLYL ALCOHOL, ETHYLENE GLYCOL, DIETHYLENE GLYCOL, POLYETHYLENE GLYCOL, GLYCEROL, BENZYL ALCOHOL, CAMPHOR.

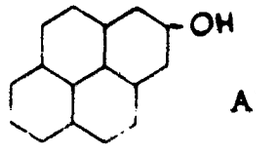
3.2 Hydroxy derivatives of aromatic and heterocyclic compounds are named from the hydrocarbon or the heterocycle and the term hydroxy



PYRIDINE 11/HYDROXY 12



ANTHRACENE 11/HYDROXY 12



ARENE 11/HYDROXY 12

Exceptions: PHENOL, NAPHTHOL, CRESOL

NOTE The notation BENZENE 11/HYDROXY 12, designates two or more hydroxy groups on the benzene ring.

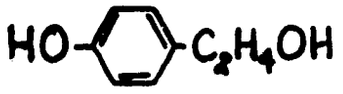
The order of precedence of functions is followed:

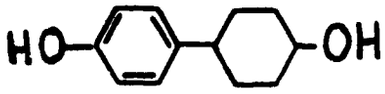
$HOCH_2CH_2NH_2$ ETHANOL 11/AMINO 12

$HOCH_2CH_2COOH$ PROPANOIC ACID 11/HYDROXY 12

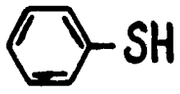
Exception:

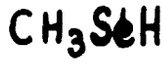
Phenol takes precedence over alcohols

 PHENOL 11/ETHYL 12/HYDROXY 23

 PHENOL 11/CYCLOHEXYL 12/HYDROXY 23

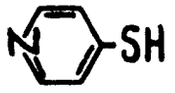
3.3 In Sulfur and Selenium derivatives the endings thiol, selenol, etc. are used.

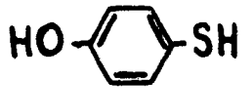
 BENZENETHIOL

 METHANESELENOL

$CH_3-(CH_2)_9-CH_2SH$ ALKANETHIOL

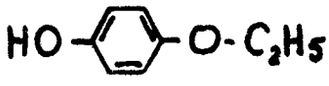
The group -Sh as a substituent is named MERCAPTO

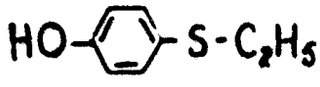
 PYRIDINE 11/MERCAPTO 12

 PHENOL 11/MERCAPTO 12

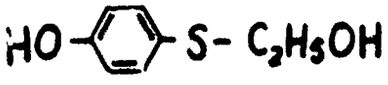
$HS-CH_2-COOH$ ACETIC ACID/MERCAPTO 12

3.4 The following conventions are also followed

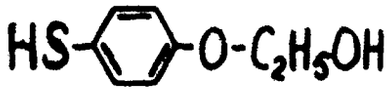
 PHENOL 11/ETHOXY 12

 PHENOL 11/THIO 12/ETHYL 23

$HO-CH_2CH_2CH_2-OCH_3$ PROPANOL 11/METHOXY 12
$HS-CH_2CH_2CH_2-O-CH_3$ PROPANETHIOL 11/METHOXY 12

 SULFIDE 11/PHENYL 12/EHTYL 12/HYDROXY 23

$HO-CH_2-CH_2-CH_2-O-CH_2OH$ ETHER 11/PROPYL 12/METHYL 12/HYDROXY 23

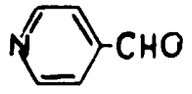
 ETHER 11/PHENYL 12/ETHYL 12/HYDROXY 23

MERCAPTO 23

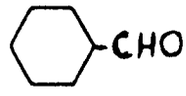
4. ALDEHYDES AND KETONES

4.1 ALDEHYDES. The names of aldehydes are formed from the hydrocarbons and the ending "AL": PROPALAL, BUTANAL, ALKANAL.
Exceptions: FORMALDEHYDE, ACEDALDEHYDE, ACROLEIN.

CYCLIC, AROMATIC and HETEROCYCLIC ALDEHYDES are named from the base compound and the term CARBOXALDEHYDE.



PYRIDINECARBOXALDEHYDE

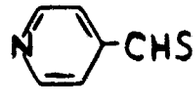


CYCLOHEXANECARBOXALDEHYDE

Exceptions: BENZALDEHYDE, FURFURAL

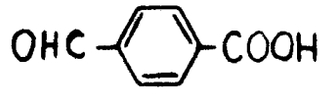
Sulfur substituted aldehydes follow the same rules of nomenclature used in sulfur substituted acids, and amides.

i.e. CH_2-CH_2-CH_2-CHS — BUTANETHIAL
CH_3-CHS — THIOACETALDEHYDE



PYRIDINETHIOCARBOXALDEHYDE

The order of precedence of functions is followed. The corresponding substituent group is ALDEHYDE.

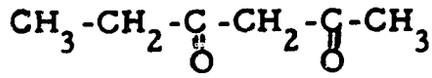


BENZOIC ACID 11
METHYL 12
ALDEHYDE 23

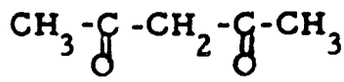
4.2 KETONES. The term KETONE 11 is used as a basic structure. The substituent group is KETO. The names of Ketones are formed from the term KETONE 11 and the corresponding alkyl radicals.

i.e. 2-BUTANONE CH_3-CH_2-$\overset{O}{\overset{\|}{C}}$-$CH_3$ KETONE 11/ETHYL 12/METHYL 12
Exceptions: ACETONE, BENZOPHENONE, ACETOPHENONE

DIKETONES are named from the hydrocarbons and the term KETO 12.

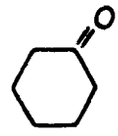


HEXANE 11/KETO 12

Except 

ACETYLACETONE

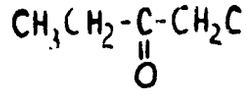
CYCLIC KETONES are named from the base compound and the term KETO.



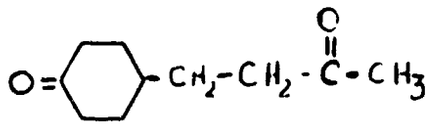
CYCLOHEXANE 11/KETO 12

Exceptions: BENZOSEMIQUINONE, QUINONE, NAPHTHOQUINONE

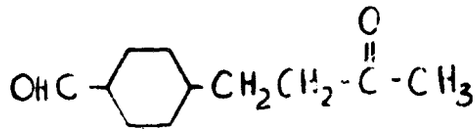
The order of precedence of functions is maintained



PENTANAL 11/KETO 12

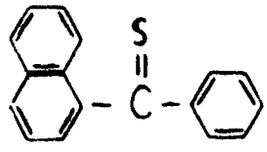


KETONE 11
METHYL 12
ETHYL 12
CYCLONEXYL 23
KETO 34



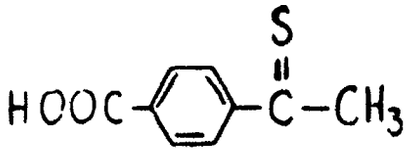
CYCLOHEXANECARBOXALDEHYDE 11
BUTYL 12
KETO 23

Sulfur substituted Ketones (Thioketones or Thiones) are named as follows:



THIONE 11
PHENYL 12
NAPTHTHYL 12

When functions higher in the order of precedence are present, the terms THIOXO 12, THIOXO 23 etc. are used.



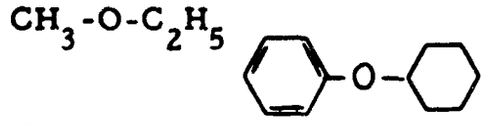
BENZOIC ACID 11
THIOXO 12
METHYL 23

4.3 KETENES

The term KETENE 11 is used as a basic structure.

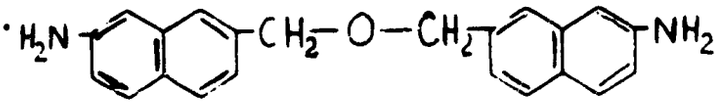
5. ETHERS

5.1 The term ETHER 11 is used as a basic structure

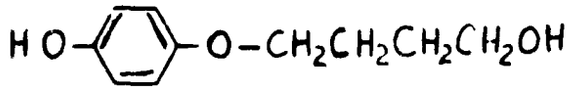


ETHER 11/METHYL 12/ETHYL 12
ETHER 11/PHENYL 12 /CYCLOHEXYL 12

However, in the presence of other functional groups, the use of the term ETHER 11 is dictated by reasons of symmetry and convenience.

i.e. 

ETHER 11/METHYL 12/NAPHTHYL 23/ AMINO 34/ BIS



ETHER 11/ PHENYL 12/HYDROXY 23 /BUTYL 12

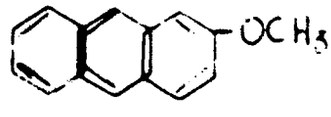
In all other cases the terms alkoxy and aryloxy are used. Common names retained are: METHOXY, ETHOXY, PROPOXY, BUTOXY, PHENOXY

i.e. $H_2N-CH_2-CH_2-CH_2-OCH_3$ AMINE P 11
PROPYL 12
METHOXY 23

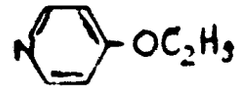
$CH_3-\overset{O}{\overset{\|}{C}}-CH_2-CH_2-OC_2H_5$ KETONE 11
METHYL 12
ETHYL 12
ETHOXY 23

CH_3O-CH_2-COOH ACETIC ACID 11
METHOXY 12

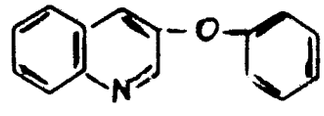
Alkoxy and aryloxy derivatives of polycyclic hydrocarbon or aromatic compounds are named from the hydrocarbon or the heterocycle.



ANTHRACENE 11
METHOXY 12

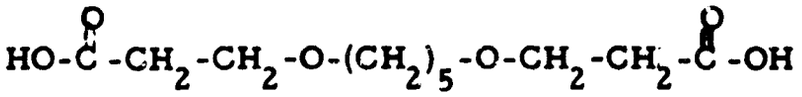


PYRIDINE 11
ETHOXY 12



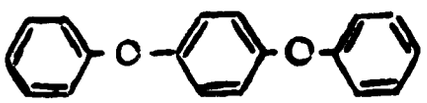
QUINOLINE 11
PHENOXY 12

In more complicated structures the term OXY is used

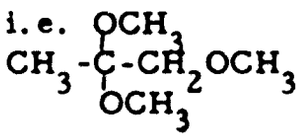


PROPANOIC ACID 11
OXY 12
POLYMETHYLENE 23
BIS

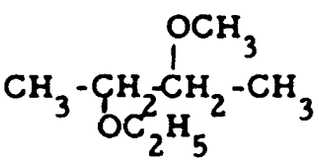
5.2 POLYPHENYL ETHERS is the index term used for compounds of the form



5.3 POLYETHERS. Polyethers are named from the hydrocarbon and the appropriate alkoxy or aryloxy term. Thus the term BENZENE 11/ETHOXY 12 indicates two or more ethoxy groups on the Benzene ring.

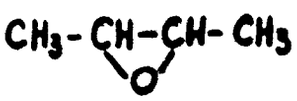
i.e. 

PROPANE 11/METHOXY 12

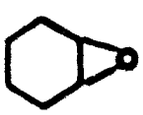


BUTANE 11/ETHOXY 12/ METHOXY 12

5.4 EPOXY COMPOUNDS. Names of epoxy compounds are formed from the hydrocarbon or the radical and the term epoxy.

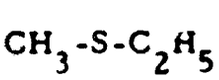


BUTANE 11/EPOXY 12

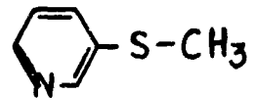


CYCLOHEXANE 11/EPOXY 12

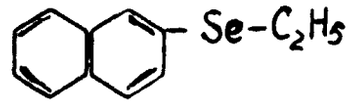
5.5 Sulfur and Selenium derivatives of the ethers are named as follows:



SULFIDE 11/METHYL 12/ETHYL 12



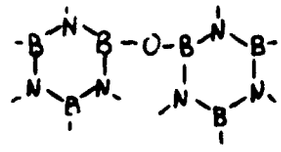
PYRIDINE 11/THIO 12/METHYL 23



NAPHTHALENE 11/SELENO 12/ETHYL 23

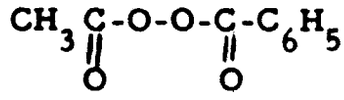
C_2H_5-Se-C_3H_7 SELENIDE 11/EHTYL 12/PROPYL 12

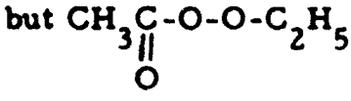
5.6 OXIDES-The term OXIDE 11 is used when one or both atoms connected to the oxygen are other than carbon

i.e.  OXIDE 11
BORAZYL 12

5.7 PEROXIDES. Peroxides of simple organic radicals of the form R-O-O-R are named from the term PEROXIDE and the names of the radicals.

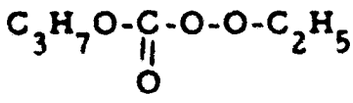
i.e. CH_3-O-O-C_2H_5 PEROXIDE 11/METHYL 12/ETHYL 12

 PEROXIDE 11/ACETYL 12/BENZOYL 12

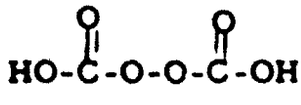
but  PEROXYACETATE 11/ETHYL 12/ESTERS

5.8 PEROXY ACIDS

CH_3COOOH PEROXYACETIC ACID

 PEROXYCARBONATE 11/ETHYL 12/ PROPYL 12/ESTERS

Peroxydiacids are named from the terms PEROXIDE and CARBOXYLATE with the appropriate connectors.

 PEROXIDE 11/CARBOXYLATE 12

6. AMMONIA AND DERIVATIVES

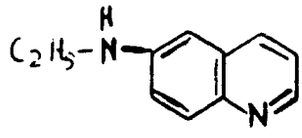
6.1 AMMONIUM COMPOUNDS. Quaternary ammonium compounds are named AMMONIUM SALT 11. They are always used as basic structures.

6.2 AMINES. Basic structures used are AMINE P 11 for primary amines, AMINE S 11 for secondary amines and AMINE T 11 for tertiary amines. Exception ANILINE.

In the presence of functions higher in the order of precedence the terms ANINO 12, AMINO 23, etc. are used.

Amines of polycyclic hydrocarbons or of heterocyclic compounds are named from the hydrocarbon or the heterocycle.

N-Substituted amines are so designated.

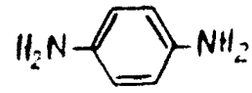


QUINOLINE 11
AMINO 12
N-ETHYL 23

6.3 POLYAMINES

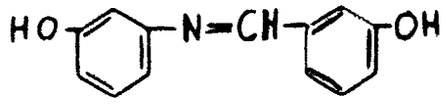
6.3.1 Polyamines are named from the hydrocarbon and the term AMINO 12

$H_2N-CH_2-CH_2-CH_2-NH_2$ PROPANE 11/AMINO 12

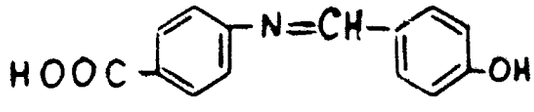
 BENZENE 11/AMINO 12

6.3.2 Linear polyamines containing recurring amino groups retain their names: DIETHYLENETRIAMINE, TETRAETHYLENEDIAMINE, etc.

6.4 IMINES- The rules used in AMINE nomenclature apply. However, the use of the basic structure IMINE 11 is dictated by reasons of convenience and symmetry.



IMINE 11
PHENYL 12
BENZYLIDENE 12
HYDROXY 23



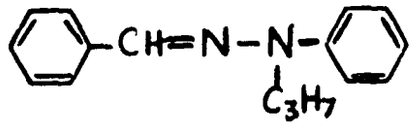
BENZOIC ACID 11
IMINO 12
N-BENZYLIDENE 23
HYDROXY 34

6.5 HYDRAZINE and DERIVATIVES

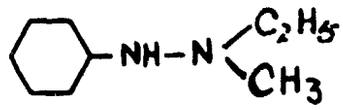
6.5.1 BASIC STRUCTURES:

HYDRAZINE 11	-NH-NH_2
	-NH-NH-
	-NH-N<
	>N-N<
AZINE 11	=N-N=
HYDRAZONE 11	>C=N-NH_2
	>C=N-HN-
	>C=N-N<
OSAZONE 11	>N-N=C-C=N-N<
HYDRAZONIUM SALT 11	$H_2N-\overset{+}{N}H_3$
	$H_2N-\overset{+}{N}<$

HYDRAZINE 11
PHENYL 12
BENZYLIDENE 12
PROPYL 12



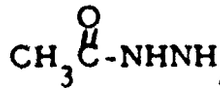
HYDRAZINE 11
CYCLOHEXYL 12
ETHYL 12
METHYL 12



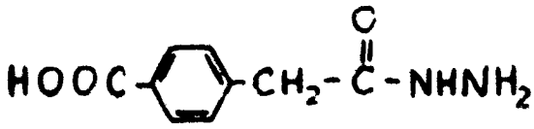
ACETIC ACID 11
HYDRAZINO 12
N-METHYL 23

$HOOC-CH_2-NH-NH-CH_3$

6.5.2 HYDRAZIDES. Hydrazides are named as hydrazine derivatives.

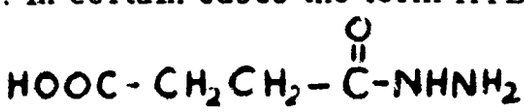


HYDRAZINE 11
ACETYL 12



BENZOIC ACID 11
ACETYL 12
HYDRAZINO 23

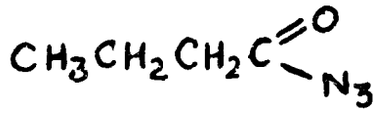
(Note: In certain cases the term HYDRAZIDO 12 may be used i.e.



PROPIONIC ACID 11
HYDRAZIDO 12)

7. AZIDES

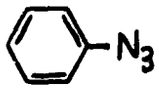
Basic structure AZIDE 11 usually used with acyl radicals



AZIDE11/BUTANOYL 12

In naming all other compounds the terms AZIDO 12, AZIDO 23, etc. are used

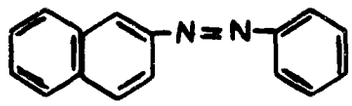
e.g. $C_2H_5N_3$ ETHANE 11 / AZIDO 12



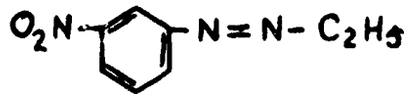
BENZENE 11/AZIDO 12

8. AZO and AZOXY COMPOUNDS

8.1 AZO and azoxy compounds are named from the basic structures AZO 11 and AZOXY 11 and alkyl or aryl radical



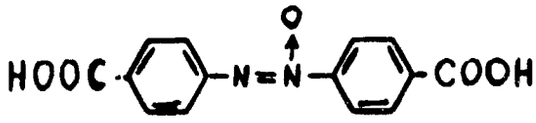
AZO 11
NAPHTHYL 12
PHENYL 12



AZO 11
PHENYL 12
ETHYL 12
NITRO 23

Exceptions: AZOBENZENE and AZOFULVENE

In presence of functions of higher order of precedence, the terms AZO 12 and AZOXY 12 are used.

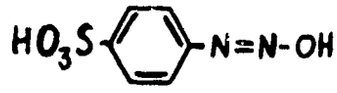


BENZOIC ACID 11
AZOXY 12
BIS

8.2 DIAZO Compounds of the type R-N=N-X where X=OH, CN, OR SO_3H etc. are named from the corresponding basic structure and the term DIAZO 12, DIAZO 13, etc.

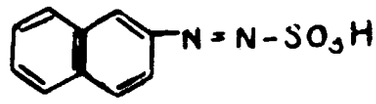
Common name retained: DIAZOMETHANE CH_2N_2

Examples:



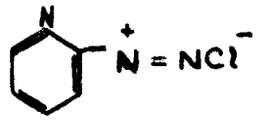
SULFONIC ACID 11
PHENYL 12
DIAZO 23
HYDROXY 34

ACETATE 11
ETHYL 12
DIAZO 12



SULFONIC ACID 11
DIAZO 12
N-NAPHTHYL 23

8.3 DIAZONIUM SALTS of the type RNNX are named from the basic structure DIAZONIUM SALT 11



DIAZONIUM SALT 11
PYRIDYL 12

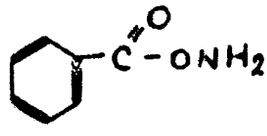
9. HYDROXYLAMINE and DERIVATIVES

9.1 The term HYDROXYLAMINE 11 is used as a basic structure. N-substituted hydroxylamines are so designated.

e.g. 

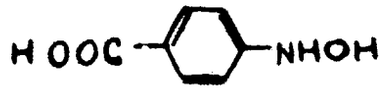
HYDROXYLAMINE 11
N-PHENYL 12

HYDROXYLAMINE 11
METHYL 12
N-METHYL 12



HYDROXYLAMINE 11
BENZOYL 12

In the presence of functions higher in the order of precedence the term HYDROXYLAMINO 12 is used.



BENZOIC ACID 11
HYDROXYLAMINO 12

NOTE: However, the term HYDROXYLAMINE takes precedence over an acid when the substitution occurs at the carboxyl group.

e.g.	$HONHCH_2COOH$	ACETIC ACID 11 HYDROXYLAMINO 12
but	$CH_3CONHOH$	HYDROXYLAMINE 11 N-ACETYL 12

9.2 OXIMES The term OXIME 11 (C=NOH) is used as a basic structure

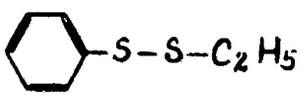
$(CH_3)_2C{=}NOH$ OXIME 11/METHYL 12

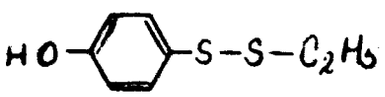
10. SULFUR COMPOUNDS

10.1 SULFIDES- Simple sulfides of the form R-S-R are discussed in 5, ETHERS

10.2 Disulfides and polysulfides -SS- $-S_n-$ are named from the basic structures DISULFIDE 11 and POLYSULFIDE

When functions higher in the order of precedence are present, the terms DITHIO 12, POLYTHIO 12, are used

Examples:  DISULFIDE 11/PHENYL 12/ETHYL 23

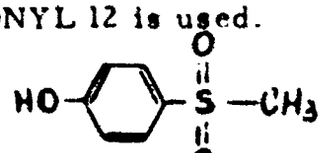
but  PHENOL 11/DITHIO 12/ETHYL 23

10.3 SULFONAMIDES and SULFINAMIDES (See 2.3.5, AMIDES)

10.4 SULFONES- Sulfones are named from the basic structure SULFONE 11 and the corresponding alkyl or aryl radicals.

e.g.	$(C_6H_5)\,SO_2$	SULFONE 11 PHENYL 12

In presence of functions higher in the order of precedence, the term SULFONYL 12 is used.

e.g.  PHENOL 11/SULFONYL 12/METHYL 23

10.5 SULFOXIDES- Nomenclature is the same as in sulfones, Basic structure S=O SULFOXIDE 11, Substituent S=O SULFINYL 12, etc.

10.6 THIONES (THIO-KETONES) (See 4.2, KETONES)

10.7 THIOLS (MERCAPTANS) (See 3.3, SULFUR and SELENIUM)

10.8 SELENIUM COMPOUNDS - The sulfur compounds nomenclature rules are followed:

11. BORON COMPOUNDS

11.1 BORON HYDRIDES - Basic structures BORANE BH_3, DIBORANE B_2H_6

11.1.1 a. Alkyl and Aryl substitute Boranes

CH_3-BH_2	BORANE 11/METHYL 12
$C_6H_5-B(CH_3)(C_2H_5)$	BORANE 11/METHYL 12/PHENYL 12/ETHYL 12

b. Radicals H_2B - BORYL, $(CH_3)_2$-B-BORYL 12/METHYL 23

11.1.2 HYDROXY substituted Boranes

a. Dihydroxy substituted boranes are called BORONIC ACIDS

$HB-(OH)_2$	BORONIC ACID
$(CH_3)_2B-(OH)_2$	BORONIC ACID 11/METHYL 12
$(C_2H_5)_2B-OCH_3$	BORONATE 11/ETHYL 12/METHYL 12

b. Monohydroxy substituted boranes are called BORINIC ACIDS

H_2B-OH	BORINIC ACID
$(CH_3)_2B-OH$	BORINIC ACID 11/METHYL 12
$(C_2H_5)_2B-OCH_3$	BORINATE 11/METHYL 12/ETHYL 12

11.1.3 AMINO substituted Boranes

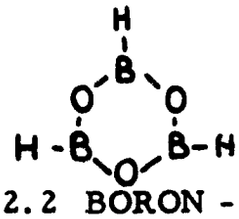
$CH_3-BH-NH_2$	BORANE 11/METHYL 12/AMINO 12
$(C_2H_5)_2B-NH(CH_3)$	BORANE 11/ETHYL 12/AMINO 12/N-METHYL 23

Similarly, phosphino substituted boranes are fragmented as follows:

$(C_2H_5)_2B-PH$	BORANE 11/ETHYL 12/PHOSPHINO 12
$(C_2H_5)_2B-PH(CL)(CH_3)$	BORANE 11/ETHYL 12/PHOSPHINO 12/ CHLORO 23/METHYL 23

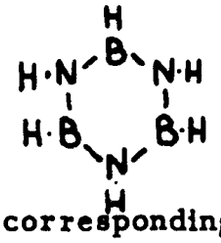
11.2 CYCLIC COMPOUNDS

11.2.1 BORON - OXYGEN COMPOUNDS



BOROXINE

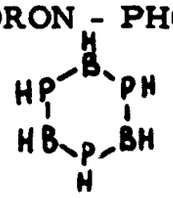
11.2.2 BORON - NITROGEN COMPOUNDS



BORAZINE

The corresponding radical is called BORAZYL

11.2.3 BORON - PHOSPHORUS



BOROPHINE and the radical BOROPHINYL

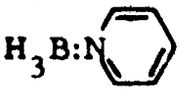
For a more detailed treatment of the Boron - Phosphorus compounds P. Kokoropoulos and S. L. Eveslage "Proposed Nomenclature of the Boron - Phosphorus Organic Compounds", to be published.

11.3 ADDITION COMPOUNDS

Compounds of boranes with Lewis bases are named as follows:

$H_3B{:}NH_3$ BORANE - AMINE

$H_3B{:}PH_3$ BORANE - PHOSPHINE

 BORANE - PYRIDINE

Addition compounds are always considered basic structures.

$(CH_3)_3B{:}N(C_2H_5)_3$ BORANE - AMINE 11/METHYL 12/ETHYL 12

 BORANE - AMINE 11/PHENYL 12/ METHYL 12/CARBOXYLATE

12. PHOSPHORUS COMPOUNDS

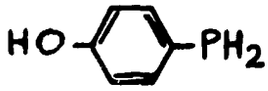
12.1 Phosphorus Hydrides

PHOSPHINE PH_3, PHOSPHORANE PH_5, DIPHOSPHINE $H_2P\text{-}PH_2$

and the radicals: PHOSPHINO - PH_2, PHOSPHORANYL - PH_4

e.g. CH_3-PH_2 PHOSPHINE 11/METHYL 12

$(C_2H_5)_2$-PH_3 PHOSPHORANE 11/ETHYL 12

 PHENOL 11/PHOSPHINO 12

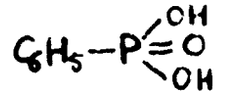
12.2 PHOSPHINE DERIVATIVES

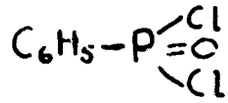
PHOSPHINE OXIDE $H_3P{=}O$, PHOSPHINE SULFIDE $H_3P{=}S$
PHOSPHINE IMIDE $H_3P{=}NH$
All basic structures.

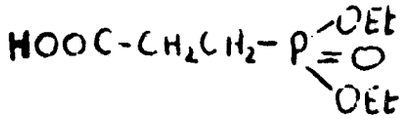
12.3 ACIDS (See also 2.2)

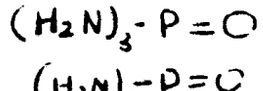
12.3.1 Nomenclature follows the rules set by the American Chemical Society (C and E News 30, 4515, (1952))

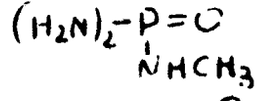
12.3.2 Examples of fragmentation

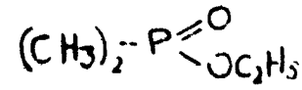
 PHOSPHONIC ACID 11/PHENYL 12

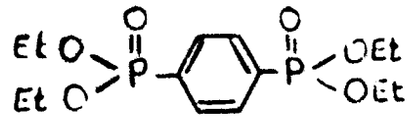
 PHOSPHONIC DICHLORIDE 11/PHENYL 12

 PROPIONIC ACID 11/PHOSPHONATE 12/ ETHYL 23

 PHOSPHORAMIDE (No connector)

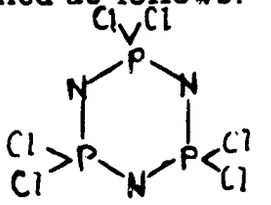
 PHOSPHORAMIDE 11/N-METHYL 12

 PHOSPHINATE 11/ETHYL 12/METHYL 12

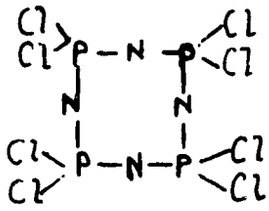
 PHOSPHONATE 11/ETHYL 12/ PHENYLENE 12/BIS

12.4 PHOSPHORUS-NITROGEN COMPOUNDS

PHOSPHINE IMIDE $H_3P{=}NH$, PHOSPHINE 11/AMINO 12 $H_2P\text{-}NH_2$ and the phosphonitrilic chlorides $(PNCl_2)_n$. The trimer and the tetramer are cyclic and are named as follows:



PHOSPHAZINE



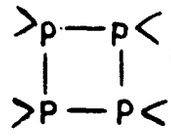
PHOSPHONITRILIC CHLORIDE TETRAMER

12.5 PHOSPHORUS-BORON COMPOUNDS (See 11.2.3)

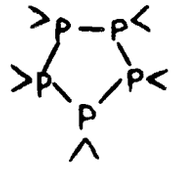
12.6 CYCLIC COMPOUNDS

The Hantzsch-Widman System of nomenclature is followed (J.A.C.S. 82, 55666, (1960))

e.g.



TETRAPHOSPHETANE



PENTAPHOSPHOLANE

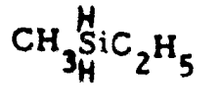
etc.

13. SILICON COMPOUNDS

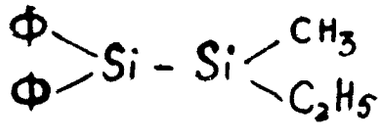
13.1 Nomenclature see Chem. and Eng. News 30, 4517, (1952)

13.2 Fragmentation

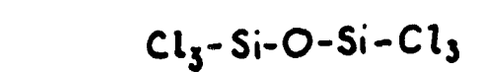
13.2.1 Basic structures



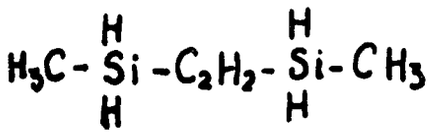
SILANE 11/ETHYL 12/METHYL 12



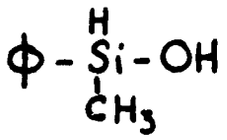
DISILANE 11/ETHYL 12/METHYL 12/ PHENYL 12



DISILOXANE 11/CHLORO 12



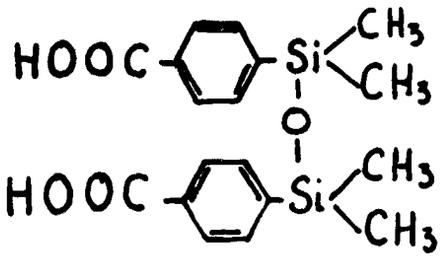
SILANE 11/METHYL 12/ETHYLENE 12/BIS



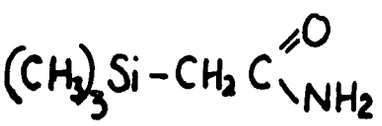
SILANOL 11/METHYL 12/PHENYL 12

SILICATE 11/PHENYL 12/ESTERS

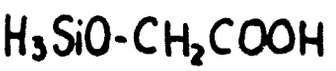
13.2.2 RADICALS SILYL - SiH_3 SILOXY H_3SiO



BENZOIC ACID 11/SILYL 12/OXO 23/ METHYL 23/BIS



ACETAMIDE 11/SILYL 12/METHYL 23



ACETIC ACID 11/SILOXY 12

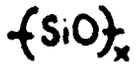
13.3 SILCON-OXYGEN COMPOUNDS with alternating silicon and oxygen atoms of the form $(Si-O)_x-Si$ are named as follows:

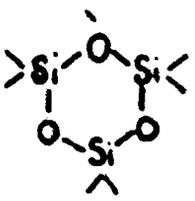
X=1 DISILOXANE

X=2 TRISILOXANE

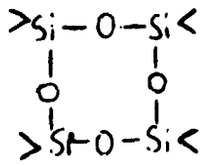
X=3 TETRASILOXANE

for X ⩾ 4 the name SILICONE is used

Cyclic compounds of the form  are named as follows:

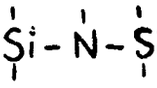


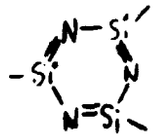
SILOXINE



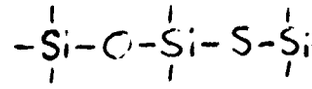
CYCLOTETRASILOXANE

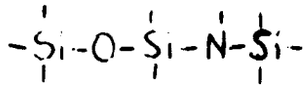
13.4 The same rules are followed for SILICON-NITROGEN compounds

e.g.  DISILAZANE

 SILAZINE

13.5 Mixed Compounds.

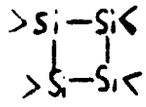
 DISILOXANE 11/THIO 12/SILYL 23

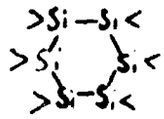
 DISILOXANE 11/AMINO 12/N-SILYL 23

The order of precedence is : SILOXANE, SILTHIANE, SILAZANE, SILANE

13.6 CYCLIC COMPOUNDS

The Hantzsch-Widman System is followed:

 TETRASILETANE

 HEXASILIN 11/HYDRO 12

13.7 The same rules hold for GERMANIUM COMPOUNDS

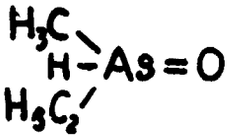
e.g. GeH_4 GERMANE -CeH_3 GERMYL

14. ANTIMONY ARSENIC and BISMUTH COMPOUNDS

14.1 Nomenclature. The same rules as in phosphorus nomenclature apply.

AcH_3 ARSINE, SbH_3 STIBINE and BH_3 BISMUTHINE and the radicals -AsH_2 ARSINO, SbH_2 STIBINO -BiH_2 BISMUTHINO. $H_3As{=}O$ ARSINE OXIDE, $H_3Sb{=}O$ STIBINE OXIDE and $H_3B{=}O$ BISMUTHINE OXIDE.

i.e. $(C_6H_5)_3Sb$ STIBINE 11/PHENYL 12

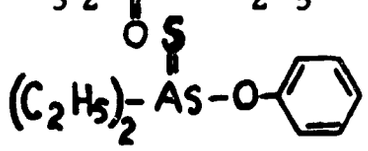

ARSINE OXIDE 11/METHYL 12/ETHYL 12

14.2 ACIDS

$RSb(=O)(OH)_2$ STIBONIC ACID 11/ALKYL 12

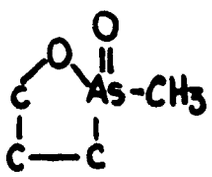
$(CH_3)_2Sb(=O)OH$ STIBINIC ACID 11/METHYL 12

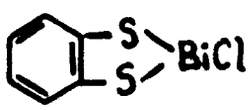
$(CH_3)_2$-As-O-C_2H_5 ARSINATE 11/METHYL 12/ETHYL 12/ESTERS


THIOARSINATE 11/ETHYL 12/PHENYL 12 ESTERS

(see also 4.5.2 ACIDS)

14.3 HETEROCYCLIC COMPOUNDS (see also 1.7 or 1.4)

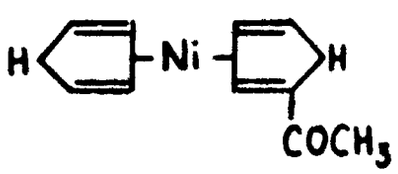

DIOXARSOLANE 11/OXO 12/METHYL 12


DITHIABISMOLE 11/BENZO 12/CHLORO 12

15. FERROCENE and ANALOGS

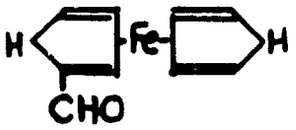
15.1 Metal-cyclopentadienyl compounds of the form are named from the metal and the term CYCLOPENTADIENYL 14.

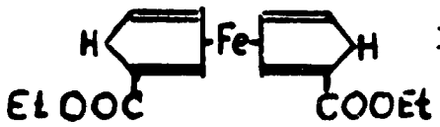
e.g. $(C_5H_5)_2OS$ OSMIUM 11/CYCLOPENTADIENYL 14

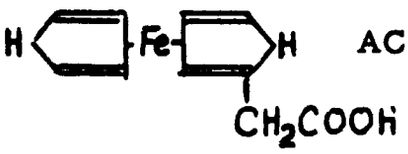

NICKEL 11/CYCLOPENTADIENYL 14/KETO 23/METHYL 34

15.2 Exception to the rule is the Iron compound which is named **FERROCENE**

Examples:  FERROCENE

 FERROCENECARBOXALDEHYDE

 FERROCENEDICARBOXYLATE 11/ETHYL 12

 ACETIC ACID 11/FERROCENYL 12

SUMMARY

The fragmentation system described is sutiable for handling a large number of organic compounds in a multidisciplinary information retrieval system, maintaining a controlled vocabulary.

The special characteristic of the system, the U. D. Connectors, permit fragmentation, indexing and searching with a high degree of accuracy so that only a minimum screening of the search output is required.

Fragmentation is so arranged that information can be retrieved either for a specific compound or for a class of compounds.

The vocabulary used is based on the internationally accepted standards of the I. U. P. A. C. systematic nomenclature.

APPENDIX II

METHODS USED IN ANALYZING METALLURGICAL INFORMATION

by

J. M. Tierney

1. GENERAL CONSIDERATIONS

The utility of a particular method of indexing is shown, to a great extent, by operations required in, and the results of, searching the system. Since the last delineation of indexing ground rules, the use of role indicators has been discontinued and the vocabulary has been updated and enlarged. Concurrent with this issue of ground rules, the vocabulary is again being updated but while being expanded in concepts is being decreased in gross number of terms.

Aside from complications involved in indexing, role indicators were discontinued because not only did the particular roles available add little to specificity in metallurgical searching, but they also made searching inordinately long, expensive and confusing. In like manner, the previous updating of vocabulary did not provide for greater selectivity in searching, but required the use of words of nearly equal value and/or of vague and/or of over-specific terms. The present updating of the vocabulary is intended to provide general searchable concepts. Recourse must be had to post-search screening if a greater degree of specificity is required.

With indexing as with any other methodology, there is some degree of inertia as regards change; a disinclination to turn from an established method to a different method. This set of ground rules is intended to provide a means of transition from the old to the new, and to serve as a manual of procedures for beginning indexers. It should be recognized that while there is one best way of doing things, each ground rule is not necessarily the best means to a particular end. Rules can be (and frequently are) changed where deemed advisable; these ground rules should not be exceptions. In fact, indexers should make a point of noting shortcomings of the present rules, methods of improving the rules, and additions and deletions which could provide greater facility in indexing and searching and, in particular, greater satisfaction in retrieval.

1.1 MATERIALS

Among the problems which have arisen concerning metallic materials those most prevalent have related to apparent over-specificity (e.g.,

numerical percentage compositions) and to insufficient postings or "see" references, which insufficiencies have required that many alternate materials (logical sum) be used in searching. Also adding to the specificity problem, in particular to the physical size of the thesaurus and posting index, were the large number of trade names encountered in indexing and inserted into the system. In this multidisciplinary, general-concept system, trade names have appeared to provide little utility.

Some "residual" problems have been encountered due to the combination of former indexing procedures with the subsequent discontinuance of the use of role indicators. The result has been that many metals have been retrieved as the objects of searches when, in reality, these particular metals were merely alloying additions, and properly indexed as such with the use of roles, but are of no interest to the search in process. It should be noted that such retrievals will remain as a minor, but irritating, problem.

1.2 PROCESSES AND PRODUCTS

Of no particular concern in indexing, but presenting some problem in searching, are the terms representing processes and products (or forms); e.g., Forging the process and Forgings the product. Although the use of the plural to distinguish between form and process has been successful for preparing readable (i.e., sentence structured) indexes, search preparation has raised the question of whether both forms are required or even desirable; due to the fact that all forms (including adjectival, where available) must be used in any search dealing with either form.

For many processes and their associated products, there is an inherent pseudo redundancy, i.e., a "stem redundancy": Casting and Castings, Coating and Coatings, Forging and Forgings. This redundancy is compounded when a document is indexed with both terms to describe a material, and the effect is furthered when both terms, as well as any applicable adjectival term, must be searched. In order to decrease pseudo, or stem, redundancy and, at the same time, to decrease the searchable vocabulary (terms which must be searched, as opposed to concepts which may be searched), "stem redundant" terms have been combined into one term for indexing, posting, and searching; e.g., Cast, Casting, and Castings have been absorbed into one concept CASTING.

1.3 PROCESSES AND PROPERTIES

In regard to metallurgical engineering, the major problems which have arisen are due to properties and processes, rather than to materials; more specifically, to pseudo properties and pseudo processes; e.g., oxidation resistance as a property and oxidation protection as a process. As with

processes and products, a similar "stem redundancy" exists between pseudo processes and pseudo propertier e.g., Corrosion Protection and Corrosion Resistance. In order to adequately search the concept CORROSION, or any of its "derivatives", all must be searched: Corroded, Corrosion, Corrosion Protection, Corrosion Resistant, Corrosion Resistance, Corrosion Testing, and Corrosivity.

In order to decrease "stem redundancy" and the size of the searchable vocabulary, thereby easing searching procedures and decreasing the number of "equal value" terms (logical sum) used in searching, such pseudo process and pseudo property terms as well as adjectives, have been combined into single terms for indexing and searching. In some instances, where it was decided that they would be of assistance to indexers and searchers, "see" references have been supplied; e.g., Corrosion Resistance (see CORROSION). Other terms, including adjectives, have been directly subsumed in the stem word with no "see" references.

1.4 TRADE NAMES

As indicated above, the indexing of commercial names has apparently added little to search utility. In addition, there is often confusion as to the precise name to be used in indexing; different authors (and different search requestors) frequently use different names for the same alloy. The cobalt base alloy, which is carried in one reference[1] as Haynes Alloy No. 25, has been indexed variously as HS-25, Cobalt HS-25, Haynes 25, and Haynes No. 25, among others. In order to circumvent this "correct" name problem, indexers must now index according to general composition as specified by "see" references. The particular alloy above, for example, should be indexed as COBALT-CR-NI-W, with an informal parenthetical notation such as any one of the above alloy names.

In addition to materials, minor problems have arisen in connection with commercial processes. These problems have been handled by using the general process as the indexing term, with a parenthetical notation of the specific process. For example, the Dow 17 process is indexed by the concept ANODIC COATING, with "Dow 17" as the parenthetical notation. In the thesaurus, this direction appears as Dow 17 Process (see ANODIC COATING).

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1. Norman E. Woldman, Engineering Alloys, 4th Edition, Reinhold Publishing Corp., New York, 1962.

2. SPECIFIC CONSIDERATIONS

2.1 FERROUS ALLOYS

2.1.1 STEELS

Because of early resistance to the use of bound terms, general types of steel such as carbon, nickel, tool, etc. could not be included in the system. This resulted in the overuse of the single term "steel" and the generation of such "steel alloy" terms as Steel-Ni and Steel-Cr. While these latter terms had potential value as means of handling the higher alloy steels and experimental alloy steels, their use to index standard steels such as 2340 and 5140 limited this value.

As regards standard steels, as a case in point there were 17 carbon steels in the system in the "1000 series" from 1005 to 1095. If required to search the file for alloy steels, these carbon steels - as well as other standard and trade named steels could only be excluded by the logical difference designation, NOT, on an individual term basis. In order to limit the number of specific terms in the searchable system, carbon points in standard designations have now been replaced by x's; e.g., both the carbon steels 1005 and 1095 are included in STEEL 10XX, while the nickel - chrominum steels 3135 and 3140 are included in the term STEEL 31XX.

There were 64 trade named steels included in the system and posted on the broad term "steel." These steels could often be designated by class of tool steel which, except from a data retrieval standpoint, is of more probable value than specific trade names. Trade designations have, where possible, now been replaced with "see" references; e.g., Potomac M (see TOOL STEEL H-13).

Such changes as above will result in a neater appearing system and will facilitate manual and mechanical searching, but may require more post-search screening if specific materials are wanted, and will definitely require more care on the part of the indexer who must not only index STEEL 31XX and TOOL STEEL H-13, but must also parenthetically note 3135, 3140 and Potomac M. The indexer must also take care not to index nickel steels as STEEL-NI. This latter designation is to be reserved for non-standard or experimental steels containing nickel as the principal, or only, alloying element (and in excess of five percent).

In order to clarify indexing procedures, but more so to facilitate searching, more general class terms have been established, such as CARBON STEELS, NICKEL-CHROMIUM-MOLYBDENUM STEELS, and TOOL STEELS. Low Alloy Steels and High Alloy Steels have not been included as terms but may be inserted in the future if warranted.

2.1.2 STAINLESS STEELS

There have been fewer problems associated with the stainless steels than with steels in general, or other types of steel in particular. Some redundancy has been required in indexing and/or searching to find a class of stainless steel. This has been due to a limited number of "see" references and to an incomplete list of groups for posting.

Trade designations have, where possible, been supplied with "see" references to the pertinent group, e.g., Greek Ascoloy (see STAINLESS STEEL 13-2); while specific types have been posted to appropriate groups, e.g., STAINLESS STEEL 201 has been posted to STAINLESS STEEL 17-4-6; and modifications of stainless steels, either types or groups, have been subsumed in the basic steel, e.g., 304ELC is carried as 304 while 18-10-Nb is carried as 18-10. In indexing stainless steels, the type (without modification designation or alloying additions) should be used where possible, as STAINLESS STEEL 316; or, where the type is unknown, the group should be used, as STAINLESS STEEL 17-7. In either case, any pertinent trade name, or modification, should be noted parenthetically on the index card.

2.1.3 OTHER IRON-BASE ALLOYS

Included in the system were specific compositional alloys, general compositional alloys, and trade named alloys. The chief problems associated with these alloys were the ever-increasing number of specific compositions with questionable increase in potential utility and the possible loss of pertinent documents when trade names were not included in compositional alloys, either by posting or by "see" references. Specific compositional alloys have now been subsumed in general compositions, and trade named alloys have been furnished with "see" references to general compositions where possible; e.g., Multimet (see IRON-CO-CR-MO-NB-NI-W).

To provide for the possibility that specific alloys may be required by a search, the indexer must parenthetically note trade names or specific compositions while using general compositions as indexing terms. In this connection, it should be noted that the number of alloying elements to be included in the composition has been arbitrarily set at five, exclusive of base metal, with a few exceptions such as Multimet, above. Also, it should be noted that alloying elements are arranged in alphabetical order, therefore when more than five are known for an alloy, the five most important (or present in largest percentages) would be chosen for inclusion in the indexed composition.

Although, when considering any one alloy, or a small group of alloys, it may appear to be more logical to list alloying elements in descending percentage order, the use of an alphabetical listing should reduce confusion

when considering alloys in general if only for the following two reasons: (1) alloy compositions, especially for experimental alloys, are sometimes described by overlapping ranges of percentages of alloying elements, and (2) a greater number of specific and general alloys can be contained in fewer terms when the terms are based on the presence of elements (alphabetical) rather than on the amounts of elements (percentages).

2.2 NON-FERROUS ALLOYS

2.2.1 LIGHT METALS

LIGHT METALS and LIGHT METAL ALLOYS have been established as new posting and searching concepts. Except for theoretical and such type reports where specific metals are not described, these two terms should not be used in indexing. When specific metals are indexed, posting to the general concepts will be automatic.

Using a density of 4.5 g/cc (20°C) as a criterion, light metals include aluminum, barium, beryllium, calcium, cesium, lithium, magnesium, potassium, rubidium, scandium, sodium, strontium, titanium, and yttrium.

2.2.1.1 ALUMINUM ALLOYS

The chief problems were apparent excess specificity and incomplete posting of trade and standard designations to general compositions. Included in the system were specific compositional alloys, general compositional alloys, standard designation alloys without temper designations, standard designation alloys with temper designations carried to the third digit, trade named alloys, and other designations.

Alloys have, where possible, been named according to the Aluminum Association's four digit method of classification and posted on general compositional alloys. Temper designations have been condensed to one digit. Specific compositions have been subsumed in general compositional alloys. Trade names have been supplied with "see" references where possible; e.g., Velodur (see ALUMINUM-CR-CU-MG-MN-ZN). Alclads have been subsumed by the standard Aluminum Association designation for the clad (not the cladding) material; e.g., Alclad 2024 is carried as ALUMINUM 2024. Modifications of standard alloys are still recognized in the system. In the future it may prove to be of value to disregard modifications, in which case, e.g., 7075, 7175, and 7275 would be carried as 7X75.

Indexers, while indexing general compositions and Aluminum Association designations with one digit tempers, must parethentically note trade names, specific compositions, and the fact that an alloy is an Alclad.

2.2.1.2 MAGNESIUM ALLOYS

The same general comments apply to magnesium alloys as to aluminum alloys except that the standard designations used are ASTM's, and modifications have been furnished with "see" references to the basic designation; e.g., Magnesium AZ-31B (see MAGNESIUM AZ-31). Indexers should use these basic designations (without modification) and a one-digit temper in indexing, but should parenthetically note the specific alloy and complete temper. As regards compositional alloys, it should be noted that rare earth alloying additions are abbreviated to RAE while Mischmetal is abbreviated as MM.

2.2.1.3 TITANIUM ALLOYS

Titanium alloys were included as specific compositions, general compositions, and as commercial designations. Specific compositions have been subsumed in general compositions while commercial designations have been furnished, where possible, with "see" references to general compositions; e.g., Titanium B-120 VCA (see TITANIUM-AL-CR-V). It should be noted that alloying elements are listed in alphabetical order. It should also be recognized that indexers will be required to parenthetically note commercial designations and specific compositions, while using only the general compositional terms as indexing terms.

2.2.1.4 BERYLLIUM and OTHER LIGHT METAL ALLOYS

Alloys were included in both specific compositional and general compositional form. Over-specificity without the attendant utility constituted the chief drawback. Specific compositions, therefore, have been subsumed in general compositions and indexers should now use only these general compositions as indexing terms with specific compositions and trade names (if any) noted parenthetically.

2.2.2 REFRACTORY METALS

REFRACTORY METALS and REFRACTORY ALLOYS have been established as posting and searching terms to include those metals with melting points greater than (not including) chromium. These include hafnium, iridium, molybdenum, niobium, osmium, palladium, platinum, rhenium, rhodium, ruthenium, tantalum, thorium, tungsten, vanadium, and zirconium.

The same general comments apply to the refractory metals as apply to other metals: specific compositional alloys have been subsumed in general compositions while trade names have been furnished with "see"

references; e.g., Fansteel 80 (see NIOBIUM-ZR). As with other alloys, general compositions should be used for indexing, with appropriate parenthetical notations.

2.2.3 OTHER NON-FERROUS ALLOYS

The same comments apply to the remaining non-ferrous alloys which have applied to the foregoing.

2.3 SPECIAL ALLOYS

2.3.1 POWDER ALLOYS

The problems peculiar to powder alloys have appeared to be: (1) identification of semi-finished and finished parts, (2) method of preparation, and (3) distinguishing powder alloys from (a) cermets, (b) composites, and (c) dispersion hardened alloys.

Powder metallurgy parts are frequently formed in a mold or die by the application of pressure and/or heat; or by such processes as vibratory compacting, isostatic pressing, vacuum hot pressing, and gas pressure sintering. Whether in finished form or to be further finished by working or machining, these parts should be indexed by use of the recently established term COMPACTS, which is not to be bound to any composition, but is to be indexed as a separate, unique term, and also by the term POWDER ALLOYS.

The preparation of a powder metal part by the application of pressure is to be described by use of the established indexing term COMPACTION. Pressing has been furnished with the "see"reference: Pressing (see COMPACTION). Powder alloys are also produced by other techniques, such as slip casting, whereby metal powders suspended in a liquid medium are cast into porous molds, usually of plaster of Paris. Structures so formed should be indexed by the concepts SLIP CASTING and POWDER ALLOYS.

In general, a powder alloy is prepared by the mixing of metal powders or of metal and ceramic powders. In the latter case, the ceramic constitutes, arbitrarily, less than 15 percent of the mixture. A cermet, also called ceramal, is "a body consisting of ceramic particles bonded with a metal."[2] According to ASTM, the ceramic phase must be present as 15 percent or more of the body.

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2. Metals Handbook, 8th Edition, Volume I, American Society for Metals, Novelty, Ohio, 1961, p.7.

In the above definition, the operative word is "bonded." A ceramic skeleton or foam, or a porous ceramic, infused or impregnated with metal, is not a cermet because the bonding of the ceramic structure is not dependent on or due to the metal. This type of structure would more accurately be called a ceramic composite because there are present two separate and distinguishable components. Metal fibers, wires, or flakes in a ceramic matrix likewise do not constitute a cermet because the metal is merely reinforcing the structure; the structure is not dependent upon the metal for bonding. This type of structure is properly indexed as COMPOSITES. Also, the process of mixing non-metallic particles in a metal powder matrix, elsewhere described as impregnation [3] results, for the purpose of this system, in a composite.

The structure resulting from the mixing of a high melting point metal in a low melting point metal matrix is properly indexed as COMPOSITES, although POWDER ALLOYS may also be a legitimate indexing term if the final form of the alloy is determined by powder metallurgical techniques rather than by melting of the lower melting point material to bind the more refractory component particules. In this latter case the concept COMPOSITES alone is correct. This type of structure should be distinguished from powder alloys in which liquid phase sintering is employed. Additions are made to the powder, or to the slip, of such materials as boron or zirconium diboride (in very small percentages) for "wetting" the surfaces of metal powder particles: primarily to improve the density of the structure. Such "wetting" should be indexed as LIQUID PHASE SINTERING as well as by POWDER ALLOYS.

Dispersion hardened alloys are not necessarily concerned with powders, either elemental metallic or metallic oxide. If hardening, or strengthening, of an alloy is due to the dispersion of added powder, or of oxides, such powders or oxides are usually added to the melt, or to a charge to be melted. Powder metallurgy ordinarily does not involve complete melting although sintering and localized fusion may occur.

2.3.2 BONDING METALS

Metals developed primarily for bonding together other metals are generally solders, brazing alloys, and welding fillers. Such metals have been carried as trade names, company name tagged materials, general compositions, and in some cases specific compositions. For indexing purposes, it has been decided to use terms composed of company name, base metal, and

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3. ibid., p. 21.

type of material; e.g., COAST METALS NICKEL BRAZING ALLOYS, and ARMCO STAINLESS STEEL WELDING FILLERS. These terms are somewhat specific, but not so specific as the many individual alloys which, it has been felt, are too specific for the value derived from carrying the individual alloys.

In addition to such indexing terms as above, posting and searching terms such as SILVER BRAZING ALLOYS and STEEL WELDING FILLERS have been established. In regards to the latter term, it should be noted that it covers all forms of welding filler: wire, rod, electrode, and non-standard forms. It should be further noted that the indexer is required to parenthetically note individual commercially named alloys and/or specific compositions where the bonding metal is not a standard type.

2.3.3 COATINGS

While the general material term Coatings has been combined with the general process term Coating into one descriptive indexing and searching term COATING, specific individual, and specific types of coatings have been retained as bond terms as, e.g., MOLYBDENUM COATINGS, ALUMINUM-NI COATINGS and SILICIDE COATINGS. In addition to compositional and types of coatings, the system also contained trade, commercial, or company named coatings. These have, where possible, been furnished with "see" references to general alloy coatings; e.g., General Electric LB-2 (see ALUMINUM ALLOY COATINGS). Other proprietary coatings have maintained the company name with the type of coating; e.g., SOLAR AIRCRAFT CERAMIC COATINGS.

Formerly, it was required that a substrate must also necessarily be indexed whenever a specific coating was indexed. Substrates, per se, have now been dropped from the vocabulary as adding little to the system, compared to the confusion and expense involved. It was also formerly the case to post specific coatings to as many terms as possible, i.e., to general composition coatings, to type of coating, to coatings in general, to specific composition, and to general composition. At present however, the feeling is that if information on a particular material is required, it is not the coating form that is wanted; or that if a coating is specified, the material in non-coating form is not wanted. When the two are kept separate, the extra effort to search two terms is more than offset by the convenience of discerning between coating and non-coating, and the result of not having both coating and non-coating retrieved when the non-coating is searched.

Pure metal coatings, as bound terms, have been posted to the pure metal, as well as to COATING, while alloy coatings, as bound terms, have been posted only to COATING. Chemical compound coatings are not indexed

as bound terms but as separate terms: the specific chemical compound and the term COATING. Although chemical compound and pure metal coatings may be retrieved by specifying the term COATING, coatings are also retrieved when COATING is not excluded by a NOT (logical difference). The posting of pure metal coatings to pure metals (which may be chemical as well as metallurgical terms) brings some degree of conformance between chemical compound term handling and metallurgical material term handling, but it provides more versatility for the metallurgical terms. While all coatings may be excluded by using NOT with the general term COATING, this may cause the rejection of a pertinent document because of the desired compound and some undesired coating being indexed in the same link. NOT may be used with individual specific coatings and thereby circumvent such a loss.

As for alloy coatings, it is usually not desired to retrieve information concerning coatings when information is required on structural metals. Also, chemical technology documents have seldom been concerned with alloys (which is not the case for pure metals). It is believed to be worth the effort to use two separate terms: specific alloy and specific alloy coatings and thereby decrease confusion as well as screening requirements.

2.4 MATERIALS SUMMARY

Among the important points to be noted are that general compositional alloys are to have the alloying elements attached hyphenetically to the base metals in alphabetical order (limited to five elements or, in extreme cases, to six), and that the indexer is required to use parenthetical notes to list trade names, commercial designations, and specific compositions.

New procedures and the collectivizing of types of materials do not make indexing any simpler, but they will cut down on error terms and the size of the searchable vocabulary, thereby aiding in searching. In addition, the indexer is less apt to become confused as to what are acceptable as indexing terms, as almost anything can be noted parenthetically; also, the direction "see", while aiding in performing a search, is also a direction to the indexer which can be read as "use", i.e. use Term B instead of Term A.

2.5 PROPERTIES

In the tensile testing of a metal, the following are generally determined during, or as a result of, the same test: ultimate strength, yield strength, elongation, and reduction in area; stress-strain diagram, proportional limit tangent modulus, secant modulus, and modulus of elasticity (Young's modulus). For purposes of simplicity in formulating a search request and in searching, and also to assist the system user and searcher to think along lines of general search requirements (where general is opposed to vague), the above "properties" have been considered on the bases of strength, ductility, and elasticity and furnished with appropriate "see" references.

The tensile "properties" ultimate strength, yield strength, stress-strain, and proportional limit have been subsumed in the concept TENSILE STRENGTH with "see" references; e.g., Tensile Proportional Limit (see TENSILE STRENGTH).

Elongation and reduction in cross-sectional area have been considered as of interest to those seeking information concerning ductility, and have been furnished with "see" references; e.g., Elongation (of Metals) (see DUCTILITY). It should be noted that elongation of non-metals is not considered to refer to the "property" "ductility" and, therefore, the reference is to "Elongation"; e.g., Elongation (of Elastomers) (see ELONGATION).

The elasticity terms tangent modulus, secant modulus, and modulus of elasticity have been furnished with "see" references to the concept TENSILE ELASTIC CONSTANTS; e.g., Tensile Modulus of Elasticity (see TENSILE ELASTIC CONSTANTS).

It should be re-emphasized that a "see" reference, as used above, is not intended to indicate that Term A is Term B, but is merely to indicate that for purposes of simplicity and generalization, Term B (in which several terms of the same general area of interest will probably be included) should be used in indexing and in searching in place of Term A.

Also sometimes determined as a result of the same tensile test above are yield point and permanent set. While the former may be considered as a facet of strength and the latter as a facet of ductility, they have not been subsumed by these larger concepts. The primary reasons for not incorporating these terms are that (1) not all metals exhibit a yield point, therefore this "property" (indexed as TENSILE YIELD POINT) is somewhat more unique than yield strength; and (2) permanent set may occur other than by tensile testing, and may refer to any plastic deformation. It has, therefore, been furnished with the "see" reference Permanent Set (see PLASTIC DEFORMATION).

The same method of collection has been followed for other mechanical properties, such as bearing, compressive, and shear. It should be noted that so-called bend properties have been absorbed by flexural properties. Indication of this is given by the reference Bend Properties (see FLEXURAL PROPERTIES). It should further be noted that indexers are required to parenthetically note specific properties in order to facilitate future post-search screening operations, in the unlikely event that an exclusive, specific mechanical property is wanted without the other "properties" which are included in the "see" reference.

2.6 PROCESSES

As a step towards generalization, while retaining some degree of specificity, certain similar processes which have common features have been incorporated into one descriptive term for indexing and searching purposes. The different types of welding, for instance, have been classified on the basis of heat source and these general types have been used, with appropriate "see" references, to subsume specific methods of welding. TIG, MIG, and submerged arc welding, among others, have been referred to the general type, arc welding, as Welding, TIG (see WELDING, ARC). In similar manner, resistance spot, resistance seam, flash, and projection welding have been referred to resistance welding as Welding, Flash (see WELDING, RESISTANCE).

Brazing, unlike welding, has not been described by either heat source or atmosphere, as Brazing, Induction or Brazing, Hydrogen; rather all brazing is referred to, both in indexing and in searching, as BRAZING. If either heat source or atmosphere is of major importance, it is to be indexed as a separate term in the same link.

It should be noted that the process of braze welding is indexed as if a form of welding, i.e., WELDING, BRAZE, but posted to both Welding and Brazing. This is not to indicate that "braze" is a heat source. If the heat source for this type of weld is a TIG torch, both WELDING, BRAZE and WELDING, ARC should be used in indexing.

Other processes which are synonymous or nearly synonymous have been combined into one concept for indexing and searching. Roll forming and shear forming, e.g., have been combined into the concept SHEAR FORMING, with an appropriate "see" reference from roll forming.

Initially, at least, indexers will need to have frequent recourse to the thesaurus in order to determine acceptable indexing terms. The need for thesaural reference should decrease as familiarity with vocabulary generalizations increases.

2.7 PRODUCTS

In general, there are two broad types of metal products in the system: (1) the products of forming, which are the "primary" forms such as castings, compacts, forgings, rods, and sheets; and (2) the products of fabrication, which are more "finished" forms such as landing gear, rocket motor cases, turbine blades, and wings. It is recognized that there may be some artificiality in the above distinction as fabrication may include forming, and vice versa. The distinction is offered, however, not as a definition, but in order to facilitate discussion.

There have been few difficulties associated with the products of fabrication, and few are anticipated. Indexers should continue to use the "form terms" of the document, tempered by the directions supplied by the thesaurus. Particular attention should be paid to the use of plurals.

As previously suggested, the chief difficulties arising from the use of the products of forming are those associated with "stem redundancy." Such terms, formerly present as plurals, should not be used in indexing or searching; rather the action form, i.e., the singulars, should be used. For instance, CASTING should be used instead of Castings . Other formed products may be indexed as indicated by the document, with attention being given to thesaural decisions on plurals: SHEETS, RODS, PLATES, for instance.

2.8 PROPERTIES, PROCESSES, PRODUCTS SUMMARY

There have been few real difficulties associated with metallurgical processes and products. The chief disadvantages have been in the way of inconveniences due to overlap of concepts, i.e., to synocepts (from "synonyms" and "concepts"), and the resulting "necessary" redundancy in indexing and/or searching which has necessitated extensive screening.

The changes which have been effected, and which have been touched upon in this report, are designed with the intention of facilitating searching and with easing screening operations. It is believed that incorporating "stem redundant" terms in one indexable, searchable concept, and also collecting all intellectually similar terms into one concept will increase the usefulness of the system from the searchers' standpoint; will assist the user in channeling his request, i.e., reducing the degree of vagueness of requests; and will reduce the confusion facing the indexer of what to use for indexing terms.

By "intellectually similar terms", above, is meant those terms which are thought of in conjunction with, or as of equal value to, one another; as being investigated or determined at the same time or by the same means. Such terms usually have been used in the AND/OR relationship in searching, i.e., as logical sum.

3. SUMMARY

The major difficulties encountered in indexing documents dealing with metallurgy and metallurgical engineering have been due to the availability and use of several separate terms which concern the same basic concepts. This over-coverage of concepts has often required the use of many "OR terms" in searching as well as indexing. Examples of such terms, or "synocepts", are the various terms used to describe or search the basic concept of corrosion.

In order to decrease the number of synocepts, to clarify indexing procedures, and to facilitate searching, great use has been made of "see" references which serve to collect several synocepts into one indexable, searchable concept.

In addition to the synocepts, many very specific terms have long been present, as well as being constantly generated as the result of indexing operations. These specific terms included compositional alloys and trade names. Although exact compositions have not been included in the vocabulary for some time (having been restricted to five alloying elements each carried only to the nearest one-half percent), the general numerical compositions have been very prolific. In this latest vocabulary and ground rules revision, an attempt has been made to control the generation of new terms by limiting compositional alloys to five or six alloying elements with no percentage designation.

It may prove in the future that even the general non-numerical compositions are being generated at too great a rate for convenient inclusion in the system. In such an event, it may be required to initiate some type of connector system (similar to the old role indicators) whereby alloying elements are divorced from basis material, but still identified with the basis by means of some alphabetical or numerical indicator. This indicator would most likely have the built-in capability of indicating relative importance of the individual alloying elements.

By such means as above, the number of alloy terms would tend to approach a limit. Such a procedure, which has associated with it several problems (chiefly dealing with prior indexing efforts), has not yet been shown to be necessary or desirable by search requests, i.e., there has been no justification (other than prediction of size) for the splintering of individual alloys.

It is sometimes the case that several different company named alloys have the same general (non-numerical) composition. It has been convenient, therefore, to refer company named materials to general compositions by means of "see" references. This procedure should assist in controlling vocabulary size, as well as facilitating searching.

In the past, as contrasted with the future, there has been more freedom in the choice of terms to describe document content. Terms have been generated from three major sources: (1) directly from the document, i.e., authors' terminology; (2) indirectly from the document, i.e., indexers' preference of terminology to describe what they think the authors intend; and (3) indirectly from index terms, i.e., editors' terminology either to "correct" indexer terminology or to provide a posting term for indexed terms. Such freedom in the generation of terms increases (1) the bulk of the thesaurus, posting index, and vocabulary; (2) the quantity of error terms, i.e., the number of terms rejected by the computer as not contained in the previously accepted vocabulary; and (3) the number of terms required to be used in searching.

The rate of generation of new terms as the result of future indexing is expected to decline, although it is realized that new terms will continually be generated in order to describe new concepts or to clarify previously accepted concepts. The combination of indexer usage of the vocabulary listing or thesaurus, and the abundance of "see" references in the system should result in the need for fewer terms to describe document content in indexing and searching, as well as a leveling-off trend in vocabulary size.

APPENDIX III

PROCEDURES FOR THE NAMING AND INDEXING OF INORGANIC CHEMICALS, INDUSTRIAL CHEMICALS AND POLYMERS

by
F. L. Scheffler and M. S. Rudig

1. INORGANIC NOMENCLATURE

Nomenclature for inorganic chemicals follows the I. U. P. A. C. except that neither valence states nor stoichiometry in inorganic compounds is indicated. For example the term COPPER CHLORIDE will be used rather than cupric chloride, copper (11) chloride, cuprous chloride, or copper (1) chloride. Exceptions to this general rule are: CARBON MONOXIDE, CARBON DIOXIDE, CARBON DISULFIDE, CARBON TETRACHLORIDE, CARBON TETRABROMIDE, CARBON TETRAIODIDE, SULFUR MONOXIDE, SULFUR DIOXIDE, SULFUR TRIOXIDE, SILICON MONOXIDE, and SILICON DIOXIDE. The valence state of ions is indicated where applicable as, CHROMIUM (111) ION, COBALT (11) ION, VANADIUM (V) ION. All oxides are named with the word "oxide", e.g. MAGNESIUM OXIDE rather than magnesia, and ALUMINUM OXIDE rather than alumina. The treatment of ceramic materials and intermetallic systems appears in Appendix IV.

Polyatomic ions are indicated by listing the atoms without indicating the stoichiometry, e.g. NaH_2PO_4 and Na_2HPO_4 are named as SODIUM HYDROGEN PHOSPHATE, and $Mg(OH)Cl$ is MAGNESIUM HYDROXIDE CHLORIDE. Polyatomic cations are named in accordance with I. U. P. A. C. practice; e.g. S_2O_5ClF is named PYROSULFURYL CHLORIDE FLUORIDE and UO_2I_2 is named URANYL IODIDE. Inorganic coordination compounds are presently handled in the same manner as organometallic compounds applying connectors; e.g. $LiBF_4$ is named LITHIUM SALT 11/BORATE SALT 11/FLUORO 12; $NH_4Cr(SCN)_4(NH_3)_2$ is AMMONIUM SALT 11/CHROMATE SALT 11/AMMINE 14/THIOCYANATO 14. Coordination compounds represent an important special class of compounds and further study of improved methods of handling is anticipated.

2. INDUSTRIAL CHEMICALS

Industrial chemicals constitute problems for the information analyst because of the wide spectrum of materials included and the number of ways by which these materials are referred to commercially. Industrial chemicals

include oils, lubricants, greases, hydraulic fluids, fuels, sealants, organic coatings, fibers, textiles, and specialty chemicals such as fuel additives, lubricant additives, antioxidants, ultraviolet inhibitors, corrosion inhibitors, pigments, etc. It is important that consistent means of handling industrial chemicals be employed.

2.1 OILS

The term oils is ambiguous because of its generality and different meanings to people engaged in various disciplines. Oils may refer to petroleum base materials, vegetable oils, hydraulic fluids, drying oils, lubricants, vehicles, etc. There are a number of reports that refer to oils of undisclosed composition which have AFML designations, for example, OIL, MLO 57-314. In the revised vocabulary, such materials are indexed as OIL, MLO 57 which includes any and all oils in the MLO 57 series. Military specification materials (other than qualification reports) are entered with the material type followed by the appropriate specification number, as, OIL, MIL-O-7808. Trade-named oils are entered as OILS.

2.2 LUBRICANTS

Lubricants may be classified as dry film lubricants such as graphite and molybdenum disulfide cemented with a ceramic binder, oils as from petroleum fractions, greases which may be higher molecular weight petroleum fractions or oils to which thickeners have been added, or gases such as air or nitrogen used in gas lubrication systems. The following lubricant and related terms are contained in the revised vocabulary: LUBRICANTS, DRY FILM LUBRICANTS, LUBRICATION, LUBRICATION SYSTEMS, GREASES, OILS, LUBRICANT ADDITIVES, GAS BEARINGS, and GAS LUBRICATION SYSTEMS. Appropriate generic relationships are included in the thesaurus to provide the desired degree of specificity or generality for the search specialist. In indexing it is important for the indexer to include the term LUBRICANTS in conjunction with specific materials used as lubricants which are not automatically posted generically. Materials Lab compounds or military specification materials are indexed as was indicated for oils; e.g. GREASE, MLG 51 or LUBRICANT, MIL-L-5656. Trade-named lubricants are indexed by the appropriate type of material, as, GREASES, OILS, and DRY FILM LUBRICANTS.

To improve search flexibility, the generic term FUEL-LUBRICANT PROPERTIES was created. This term includes specific properties peculiar to lubricants and fuels such as FLASH POINT, LUBRICANT PENETRABILITY, and API GRAVITY. Other properties may be searched individually, as, VISCOSITY, DENSITY, and LUBRICITY. The term LUBRICANT ADDITIVES was generated to include materials which are especially designed for improving lubricant properties such as extreme pressure agents, detergents, and viscosity improvers. Indexing examples follow:

Example 1: A series of organic compounds was evaluated as base fluids for high temperature lubricants. The thermal stability, oxidation resistance, flash point, smoke point, viscosity and density were determined. Polyphenyl ethers are thermally stable. Several pyrazine compounds are oxidation resistant, but they are not as thermally stable as the polyphenyl ethers.

Link			Terms
A	B	C	FUEL-LUBRICANT PROPERTIES
A	B	C	VISCOSITY
A	B	C	DENSITY
A	B	C	LUBRICANTS
		A	POLYPHENYL ETHERS
		A	AMINE T 11
	B	A	PYRAZYL 12
		A	PHENYL 12
		B	ETHER 11
		C	PYRAZINE 11
		B	BIS
		C	N-METHYL 12
		B	N-METHYL 23
A	B	C	OXIDATION
A	B	C	THERMAL STABILITY
A	B	C	TEMP. 090

Example 2: A number of AFML greases were screened to find basic greases suitable for space vehicles. Low volatility was the primary criterion for selection. Lubricant additives were added to the basic greases to increase the radiation stability and thermal stability. Five grease formulations had only marginal performance in the vacuum chamber bearing test rig.

Link	Terms
A	LUBRICANT ADDITIVES
A	BEARINGS
A	VACUUM
A	FORMULATION
A	SPACE VEHICLES
A	VOLATILIZATION
A	VOLATILITY
A	THERMAL STABILITY
A	RADIATION STABILITY
A	GREASE, MLG 59
A	GREASE, MLG 60
A	GREASE, MLG 61
A	GREASE, MLG 62

2.3 HYDRAULIC FLUIDS

Hydraulic fluids are treated similarly to the materials discussed in the preceding sections. Typical examples are: HYDRAULIC FLUID, MIL-H-5606, and HYDRAULIC FLUID, MLO 62.

Example 3: A study was performed to determine the effect of gamma radiation on various hydraulic fluids. Several antirads were added to improve the radiation stability of the hydraulic fluids.

Link	Terms
A	IRRADIATION
A	RADIOLYSIS
A	GAMMA RADIATION
A	HYDRAULIC FLUID, MLO 61
A	HYDRAULIC FLUID, MLO 62
A	HYDRAULIC FLUID, MIL-H-5606
A	HYDRAULIC FLUID, MIL-H-4237
A	VACUUM
A	TEMP. 090
A	ANTIRADS
A	RADIATION STABILITY

2.4 FUELS

The term FUELS in the revised vocabulary includes such materials as gasoline, jet fuel, nuclear fuel, coal, natural gas, etc., which are used in jet engines, furnaces, nuclear reactors, etc. The term PROPELLANTS is used exclusively for rockets and similar type devices and will be discussed in the following section. Terms employed in the revised vocabulary related to fuels, in addition to specific materials, are: FUELS; FUEL, NUCLEAR; FUEL, AVIATION; FUEL ELEMENTS; FUEL SYSTEMS. Military specifications. Materials Lab designations, and trade-named fuels are handled as indicated previously; i.e. FUEL, MLF 61, FUEL, MIL-F-3136; FUELS. The generic term FUEL-LUBRICANT PROPERTIES was added to the vocabulary and is discussed in the section on lubricants. The term FUEL ADDITIVES is used to include such items as anti-knock additives, gum inhibitors and anti-fouling additives.

Example 4: A series of hydrocarbons was evaluated for use as endothermic fuels for hypersonic jet aircraft. The heat sink effectiveness was of primary concern. The thermal cracking which occurred during heat transfer did not affect the fuel properties or the combustion characteristics appreciably.

Link		Terms
	B	COOLING SYSTEMS
A	B	FUEL, AVIATION
	B	HEAT TRANSFER
A	B	EVALUATION
A		BURNING
A		COMBUSTION
	B	COOLANTS
	B	HEAT SINK
A		FUEL-LUBRICANT PROPERTIES
A		DENSITY
A	B	ENGINE, JET
A		CRACKING

2.5 PROPELLANTS

Propellants are materials which provide an energy source for the propulsion of rockets or rocket-like devices. They may be roughly classified as liquid propellants and solid propellants but the broad term is also used for advanced propulsion system materials under research for interplanetary space travel. Terms relating to propellants and rocket propulsion are: PROPELLANTS, LIQUID PROPELLANTS, SOLID PROPELLANTS, ION PROPULSION, and PROPULSION SYSTEMS. Trade-named materials are treated as indicated previously. In indexing specific materials used as propellants, the information analyst should also include the word PROPELLANTS or the appropriate equivalent. For example, unsymmetrical dimethyl hydrazine would be indexed according to the fragmentation system as HYDRAZINE 11/METHYL 12. The term LIQUID PROPELLANTS must also be included in the indexing to provide access to the document through the search term PROPELLANTS or LIQUID PROPELLANTS.

Example 5: The performance of various liquid propellant systems was investigated. The specific impulse was determined for the following oxidizer-propellant combinations: chlorine trifluoride - hydrazine; nitrogen tetroxide-unsymmetrical dimethyl hydrazine; liquid oxygen - liquid hydrogen; liquid fluorine - liquid hydrogen; chloryl fluoride - unsymmetrical dimethyl hydrazine; and chloryl fluoride - hydrazine.

Link	Terms
A	SPECIFIC IMPULSE
A	LIQUID PROPELLANTS
A	LIQUID HYDROGEN
A	LIQUID OXYGEN
A	HYDRAZINE 10
A	HYDRAZINE 11
A	METHYL 12
A	CHLORINE FLUORIDE
A	NITROGEN OXIDE
A	CHLORYL FLUORIDE
A	LIQUID FLUORINE

Example 6: The effect of the combustion of various solid propellants on the erosion and chemical interaction with rocket nozzles of pyrolytic graphite was determined for several commercially available solid propellants. One-fourth scale rocket motors were fired and the nozzles were analyzed for weight loss and chemical changes.

Link	Terms
A	COMBUSTION
A	COMBUSTION PRODUCTS
A	EROSION
A	CORROSION
A	SOLID PROPELLANTS
A	ROCKET NOZZLES
A	PYROLYTIC CARBON
A	TEMP. 150

2.6 PAINTS, VARNISHES, STRIPPABLE COATINGS, PRIMERS, SEALANTS

These terms are generally commercial materials. Trade-named items are indexed by the material, as, SEALANTS, ALUMINUM PAINTS, and STRIPPABLE COATINGS. Military specification materials are treated as indicated previously, as PRIMER MIL-P-6889.

2.7 FIBERS

Fibers are either natural or synthetic materials of threadlike structure. Materials which are natural fibers are indexed by name, SILK, COTTON, and WOOL. Materials which are not natural fibers are indexed by the material and the term FIBERS, as, STAINLESS STEEL and FIBERS. Synthetic fibers

are indexed by the type material and the term FIBERS, thus, Acrilan (polyacrylonitrile) would be indexed as ACRYLIC POLYMERS, NITRILE POLYMERS and FIBERS (see Section 3 on polymers). GLASS FIBERS is an exception to this and is maintained as a bound term. The term CLOTH is used to denote a woven structure and is used in preference to fabric which is nearly synonymous; e.g. CARBON CLOTH, GLASS CLOTH, NICKEL-AL-CU and CLOTH. Terms related to fibers are WHISKERS and FILAMENTS. These terms are used with the material; e.g. WHISKERS and ALUMINUM OXIDE, WHISKERS and IRON, FILAMENTS and BORON NITRIDE.

Example 7: Iron whiskers were grown under controlled conditions from ferrous chloride; properties of the whiskers were obtained.

Link		Terms
A		CRYSTAL GROWTH
A	B	IRON
A	B	WHISKERS
A		TEMP. 050
	B	TENSILE STRENGTH
	B	DUCTILITY

2.8 SPECIALTY CHEMICALS

There are many chemicals used commercially which may be considered specialty chemicals. As chemical technology has become increasingly complex the number of these has multiplied at a fantastic rate. It has already been indicated in previous sections that additives peculiar to a particular type of material are included under one term such as FUEL ADDITIVES. However, there are many specialty chemicals which are included in the revised vocabulary as separate entities, such as, CORROSION INHIBITORS, ANTIRADS, ANTI-FOAMING AGENTS, MICROBIOLOGICAL INHIBITORS, INSECTICIDES, etc. Trade-named materials are treated as indicated previously, as, ANTI-ICING COMPOUNDS, CLEANING COMPOUNDS, etc. It may occur in indexing that a specialty chemical is used as a type of additive. For instance, antirads may be used as lubricant additives; in such a case both the terms ANTIRADS and LUBRICANT ADDITIVES should be used in indexing.

Example 8: Several commercially available compounds were screened to determine their effectiveness as antirads in OIL, MIL-L-7808.

Link	Terms
A	OIL, MIL-L-7808
A	RADIATION STABILITY
A	ANTIRADS
A	IRRADIATION
A	GAMMA RADIATION
A	RADIOLYSIS
A	LUBRICANT ADDITIVES

Example 9: Cloudiness was observed in jet fuels which had been stored for several months. Analysis indicated that the cloudiness was traceable to a chemical reaction between various fuel additives causing precipitation. Substitution of an alternate acceptable anti-knock compound was found to overcome this difficulty.

Link	Terms
A	FUEL, AVIATION
A	COMPATIBILITY
A	FUEL ADDITIVES
A	ANTI-ICING ADDITIVES
A	PRECIPITATION
A	ANTIRADS
A	MICROBIOLOGICAL INHIBITORS
A	STORAGE

Example 10: Corrosion of faying surfaces of aircraft is a problem. Special treatment techniques are required at the rivet holes to reduce the corrosion problem. Recent studies indicate the feasibility of microencapsulation of corrosion inhibitors and subsequent adhesion to rivets; the corrosion inhibitor is released during the riveting operation. This technique is effective and is potentially more economical than present methods.

Link	Terms
A	MICROENCAPSULATION
A	CORROSION INHIBITORS
A	RIVETS
A	AIRCRAFT
A	FABRICATION

3. POLYMERS

From an information retrieval standpoint, polymer nomenclature is by no means established. The profusion with which new polymers are being synthesized and studied accentuates this problem. To achieve adequate retrievability, while maintaining a reasonable vocabulary, general classes of polymers were established to accommodate the majority of polymers, although greater specificity is employed where presently indicated, or in anticipation of future requirements. Based on past search experience, general classes of polymers are used frequently in searches pertaining to polymers; however, provision has been made so that proper search strategy will permit a reasonable degree of specificity when the search request requires it.

3.1 ADDITION POLYMERS

Addition polymers are those polymers which are formed by the addition of unsaturated molecules to each other. Addition polymers are classified into several groups according to the monomer structure.

3.1.1 VINYL POLYMERS

Vinyl polymers are based on the monomer $Z_2C=CZ_2$ where Z may be any substituent group other than a straight chain hydrocarbon. Four vinyl type polymers retain their common names. These are: POLYETHYLENE, POLYSTYRENE, POLYVINYL ALCOHOL, and POLYVINYL ACETAL (where this term refers to any acetal type). Other vinyl type polymers are indexed using the term VINYL POLYMERS with the characteristic substituents indicated in another term. For example polyvinyl chloride is included in the system as VINYL POLYMERS and CHLORINE CONTAINING POLYMERS (see Section 3.3.2).

3.1.2 ACRYLIC POLYMERS

Acrylic polymers are based on the monomer H_2C-CY where Y is -COOH, -COOR, -COF, -COCl or $-C\equiv N$. Acrylic and methacrylic polymers are handled as ACRYLIC POLYMERS with another term to describe the substituent when necessary. Polymethyl methacrylate, polymethacrylamide, polyacrylic acid, etc. would all be indexed as ACRYLIC POLYMERS. Polyacrylonitrile would be handled as ACRYLIC POLYMERS and NITRILE POLYMERS.

3.1.3 ALLYL POLYMERS

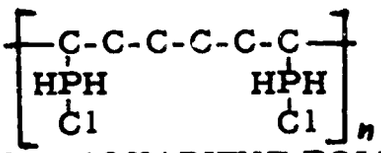
Allyl polymers are based on the monomer $H_2C=CH-CX$ where X does not classify it as an acrylic polymer and is not a straight or branched chain hydrocarbon. All allyl polymers are treated as ALLYL-X polymers. The characteristic substituent is indicated where necessary. For example, allyl phosphonium bromide polymers are handled as ALLYL-X POLYMERS and PHOSPHORUS CONTAINING POLYMERS (see Section 3.3.2).

3.1.4 ALKENE POLYMERS

Alkene polymers are based on the monomer $H_2C{=}CR$, where R is a straight or branched chain hydrocarbon. Polypropylene, polybutene, polyhexene, etc., are all named as ALKENE POLYMERS.

3.1.5 ALKADIENE POLYMERS

Alkadiene polymers are based on the monomer $Z_2C{=}CRC{=}CZ_2$. Polybutadiene, polyhexadiene, etc., are treated as ALKADIENE POLYMERS. Z may also be designated in the indexing by another appropriate term, for example:



would be indexed as ALKADIENE POLYMERS and PHOSPHORUS CONTAINING POLYMERS (see Section 3.3.2).

3.1.6 ALKYNE POLYMERS

Alkyne polymers are based on the monomer $ZC{\equiv}CZ'$. They are handled as ALKYNE POLYMERS with the substituents designated if necessary as indicated previously.

3.1.7 NITRILE POLYMERS

Nitrile polymers are based on the monomer $RC{\equiv}N$. The term refers to polymers actually polymerized through the nitrile group or to polymers containing the nitrile group as a primary substituent, as polyacrylonitrile (see Section 3.1.2). Inorganic nitriles are indexed as NITRILE POLYMERS, for example, phosphonitrile polymers.

3.2 CONDENSATION POLYMERS

Condensation polymers are formed by a type of condensation reaction such as esterification, amidation, aldol condensation, etc. To establish nomenclature uniformity, a system of classes of condensation polymers was developed.

3.2.1 PHENOLIC POLYMERS

The most common phenolic polymers are the phenol-aldehyde polymers. All polymers of this type are included in the generic term PHENOLIC POLYMERS. Phenol-formaldehyde, naphthol-formaldehyde, and resorcinol-formaldehyde are examples of PHENOLIC POLYMERS.

3.2.2 AMINE-ALDEHYDE POLYMERS

Urea-formaldehyde polymers are important commercially; however, other amines react to form condensation polymers with formaldehyde or other aldehydes. In order to include as many polymers of this type as possible, the index term used is AMINE-ALDEHYDE POLYMERS. This term includes melamine-formaldehyde polymers, urea-formaldehyde polymers and aniline-formaldehyde polymers.

3.2.3 EPOXY POLYMERS

Epoxy polymers are thermosetting materials which polymerize partially through the epoxy group. An example is the condensation product of bisphenol A and epichlorohydrin. These resins are indexed as EPOXY POLYMERS.

3.2.4 MELAMINE POLYMERS

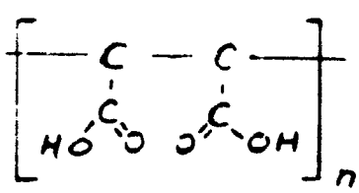
The term MELAMINE POLYMERS is used when the major constituent is known to be melamine. A typical example is melamine formaldehyde polymers which are indexed as MELAMINE POLYMERS and AMINE-ALDEHYDE POLYMERS.

3.2.5 ALKYD POLYMERS

Alkyd polymers comprise an important class of plastics. All polyesters are indexed under the term ALKYD POLYMERS. An example is polyhexamethylene adipate.

3.2.6 DICARBOXYLIC ACID POLYMERS

Condensation polymers which contain a repeating dicarboxylic acid group are indexed as DICARBOXYLIC ACID POLYMERS.



VINYL POLYMERS
DICARBOXYLIC ACID POLYMERS

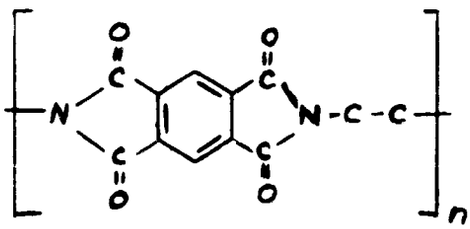
Polyamides (polyesters, etc.) formed from a dicarboxylic acid are indexed as DICARBOXYLIC ACID POLYMERS and the appropriate class. For example propylene terephthalate polymer is indexed as DICARBOXYLIC ACID POLYMERS and ALKYD POLYMERS.

3.2.7 POLYAMIDES

Polyamides are at least partially polymerized by forming amide linkages. NYLON and NOMEX are retained as separate terms, but all other polyamides are designated by the generic term, POLYAMIDES.

3.2.8 POLYIMIDES

Polyimides contain a repeating monomer unit which polymerizes at least partially through imide linkages. For example, the term POLYIMIDES is used to describe the following polymer structure:



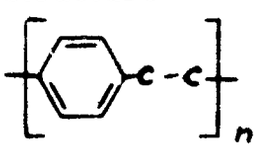
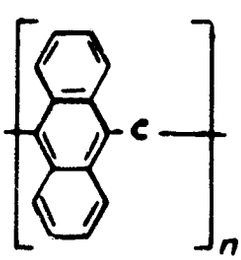
POLYIMIDES

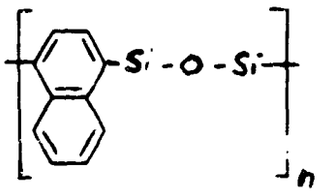
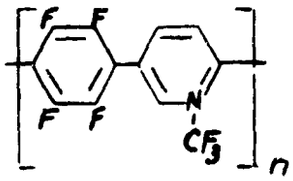
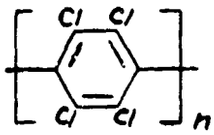
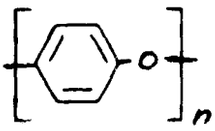
3.3 AROMATIC POLYMERS, HETEROCYCLIC POLYMERS, INORGANIC POLYMERS AND COORDINATION POLYMERS

As polymer technology has advanced, polymer structures have become increasingly complicated. This section deals with the treatment of polymers containing aromatic, heterocyclic, and non-carbon repeating units in the primary polymer chain.

3.3.1 AROMATIC POLYMERS

Aromatic polymers are those containing one or more aromatic hydrocarbon structures in the primary polymer chain. Most aromatic polymers consist of phenylene or arylene structures connected by straight chain hydrocarbon units. Such polymers are designated as PHENYL-R POLYMERS or ARYL-R POLYMERS. Polymers not of these types which contain aromatic structures are called AROMATIC POLYMERS and any other terms required to describe them sufficiently. POLYPHENYLENE is retained.

Structure	Name	Indexing
	Phenylene-ethylene Polymers	PHENYL-R POLYMERS
	Anthracene-methylene Polymers	ARYL-R POLYMERS

Structure	Name	Indexing
	Naphthalene-disiloxane Polymers	AROMATIC POLYMERS SILOXANE POLYMERS
	Perfluorophenylperfluoro methyl pyridine polymers	AROMATIC POLYMERS FLUORINE CONTAINING POLYMERS HEAT RESISTANT POLYMERS NITROGEN HETEROCYCLE POLYMERS
	Perchloropolyphenylene	POLYPHENYLENE CHLORINE CONTAINING POLYMERS
	Polyphenylene oxide	AROMATIC POLYMERS POLYETHERS

3.3.2 POLYMERS CONTAINING HALOGEN, NON-METAL, METALLOID, or METAL ATOMS

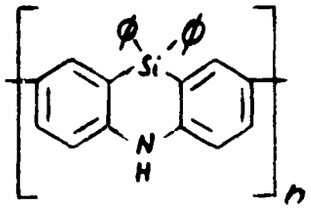
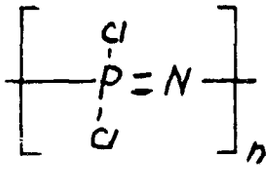
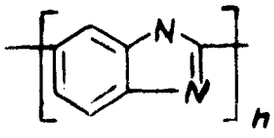
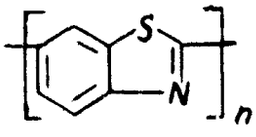
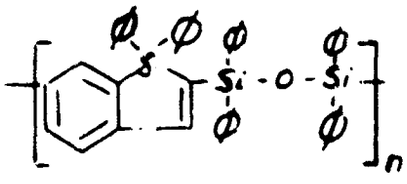
Many polymers contain atoms of elements other than carbon, hydrogen, or oxygen. Generally such elements affect the basic nature of the resultant polymer. The heteroatom may be a part of the polymer chain itself, or it may be directly attached to the polymer chain. To designate the heteroatoms, classes of polymers were established to include them. By proper search strategy, a high degree of specificity is possible even with general classes of polymers.

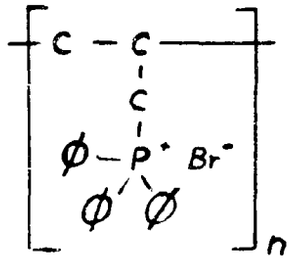
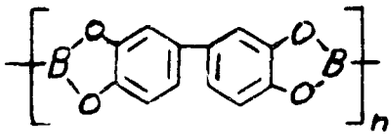
3.3.2.1 HALOGEN ATOMS

Polymers having halogen substituents are designated as CHLORINE CONTAINING POLYMERS and FLUORINE CONTAINING POLYMERS (to date bromine and iodine have not merited special polymer classes). Polyvinylidene chloride is indexed as VINYL POLYMERS and CHLORINE CONTAINING POLYMERS and polyperfluoromethacrylic acid would be handled as ACRYLIC POLYMERS and FLUORINE CONTAINING POLYMERS.

3.3.2.2 NON-METAL AND METALLOID ATOMS - HETEROCYCLIC POLYMERS

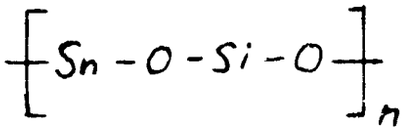
These atoms may be part of the polymer chain, or directly attached to the polymer cnain. The polymer classes are designated according to which of these situations is operative. If the heteroatoms are part of the polymer chain or directly attached to it, the polymer is handled as, for example, BORON CONTAINING POLYMERS. If the heteroatom is part of a repeating heterocyclic structure the polymer is indexed as HETEROCYCLIC POLYMERS and BORON CONTAINING POLYMERS. If the heteroatom is oxygen only, the term OXYGEN HETEROCYCLE POLYMERS is applied; if the heteroatom is nitrogen only, the term NITROGEN HETEROCYCLE POLYMERS is applied. A number of examples follow:

Structure	Name	Indexing
	Phenazasiline polymers	HETEROCYCLIC POLYMERS SILICON CONTAINING POLYMERS NITROGEN CONTAINING POLYMERS
	Phosphonitrilic chloride Polymers	PHOSPHORUS CONTAINING POLYMERS NITROGEN CONTAINING POLYMERS CHLORINE CONTAINING POLYMERS INORGANIC POLYMERS NITRILE POLYMERS
	Benzimidazole polymers	NITROGEN HETEROCYCLE POLYMERS
	Benzothiazole polymers	HETEROCYCLIC POLYMERS SULFUR CONTAINING POLYMERS NITROGEN CONTAINING POLYMERS
	Benzosilole disiloxane Polymers	HETEROCYCLIC POLYMERS SILICON CONTAINING POLYMERS SILOXANE CONTAINING POLYMERS

Structure	Name	Indexing
	Allyl phosphonium Bromide Polymers	ALLYL-X POLYMERS PHOSPHORUS CONTAINING POLYMERS
	Polydioxaboroles	HETEROCYCLIC POLYMERS OXYGEN CONTAINING POLYMERS BORON CONTAINING POLYMERS

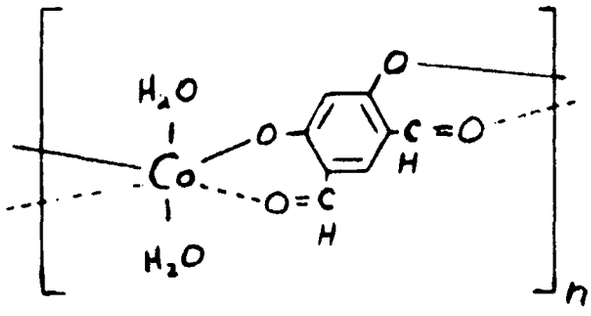
3.3.2.3 METAL ATOMS - INORGANIC POLYMERS - COORDINATION POLYMERS

Recently a number of "inorganic polymers" have become important. These polymers are derived from non-carbon atom polymer chains. The oldest inorganic polymers are the silicones. Silicones are treated independently in Section 3.5. Another example of an inorganic polymer is phosphonitrilic chloride polymer which is included in the examples of the previous section. Many inorganic polymers conatin metal atoms. All polymers containing metal atoms are indexed as METAL CONTAINING POLYMERS. An example of such a polymer is stannosiloxane polymers which has the following structure:



METAL CONTAINING POLYMERS
SILOXANE POLYMERS
INORGANIC POLYMERS
HEAT RESISTANT POLYMERS

Another type of polymer containing metal atoms is the coordination polymers which are derived from coordinate bonding as the basis of the polymer chain. An example is a cobalt chelate polymer as follows:



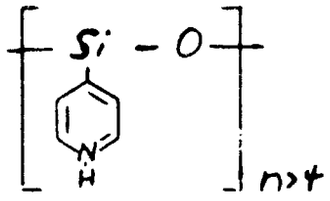
METAL CONTAINING POLYMERS
COORDINATION POLYMERS
HEAT RESISTANT POLYMERS

3.4 POLYURETHANES

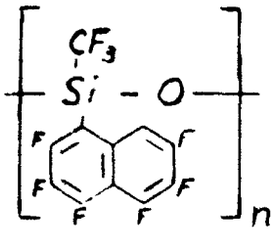
Urethane polymers in practical applications can take many forms: foams, coatings, adhesives and elastomers. The terms POLYURETHANES, POLYURETHANE ELASTOMERS, POLYURETHANE FOAMS, and POLYURETHANE ADHESIVES are maintained to describe these isocyanate resins. The major application for polyurethanes is in foams and this is by far the most frequently used term.

3.5 SILICONES

Silicones which contain the basic unit - Si-O - are an important polymer class. If the repeating unit is less than five, individual names and connectors (see APPENDIX I) are applied. If the basic repeating unit is greater than four, the term SILICONE 11 or SILICONE 10 is used. For example:



SILICONE 11
NITROGEN HETEROCYCLE POLYMERS



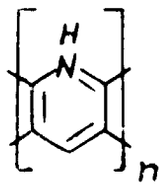
SILICONE 11
FLUORINE CONTAINING POLYMERS
AROMATIC POLYMERS

The term SILICONES is a generic posting term and is used also for trade-named silicones. Thus DOW CORNING SILICONES, TREVARNO SILICONES, etc., will be indexed by the term SILICONES.

Certain general terms relating to silicones are used where pertinent: SILICONE ADHESIVES, SILICONE COATINGS, SILICONE ELASTOMER COATINGS, SILICONE ELASTOMER FOAMS, SILICONE FOAMS, SILICONE ELASTOMERS, SILICONE GREASES, SILICONE OILS, SILICONE PAINTS and SILICONE RESINS.

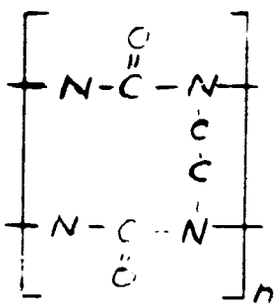
3.6 FUSED RING POLYMERS and LADDER POLYMERS

3.6.1 The generic term FUSED RING POLYMERS is used for polymers containing a repeating fused ring unit. Any other important characteristics of the monomer will be indicated in indexing. A specific example would be indexed as follows:



FUSED RING POLYMERS
NITROGEN HETEROCYCLE POLYMERS

3.6.2 Many of the more exotic polymers contain a repeating ladder structure. These polymers contain a primary repeating unit connected by a "rung" component. The term LADDER POLYMERS is used to describe them. In indexing, the structure is indicated as follows:



LADDER POLYMERS
NITROGEN CONTAINING POLYMERS

3.7 ELASTOMERS

Elastomers are polymers with rubber-like characteristics and as such are useful for certain applications. In the UDRI System of nomenclature, the concepts rubber, synthetic rubber and elastomers are grouped under the single term ELASTOMERS. The term NATURAL RUBBER is retained. For example, chloroprene would be found under ELASTOMERS. Elastomers which are characterized by important polymeric structural features should have these features indicated. For example chlorotrifluoroethylene elastomers would be indexed by ELASTOMERS, CHLORINE CONTAINING POLYMERS, and FLUORINE CONTAINING POLYMERS. This treatment is consistent with the treatment of polymers and insures uniformity.

The term TN-ELASTOMERS is used to distinguish trade-named or commercially available elastomers. B. F. Goodrich Elastomers, Acadia Elastomers, Viton A, etc., are all indexed as TN-ELASTOMERS. Viton A would also be indexed as FLUORINE CONTAINING POLYMERS. The term ELASTOMER PROPERTIES was devised to include properties pertaining to elastomers such as BRITTLE POINT, FUEL RESISTANCE, etc.

3.8 TRADE NAMES

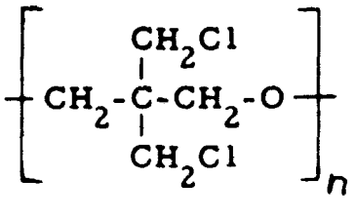
In order to accommodate a large number of documents with relatively few specific terms, trade-named polymers are not specifically designated by trade name. These polymers are indexed under the composition and/or properties. One example of a polymer trade name is as follows:

Trade Name	Indexing
CIBANITE	AMINE-ALDEHYDE POLYMERS PLASTICS

A few trade names will be retained because of their usefulness in searching. These trade names are: NYLON, TEFLON, SARAN, NOMEX and KEL-F.

3.9 POLYETHERS

The term POLYETHERS is used to include such structures as:



However, POLYETHYLENE GLYCOLS is maintained because of the usefulness of these polymers.

Polyphenyl ethers are not polymers in the strictest sense of the word, since they are only a few units long. Polyphenyl ethers are indexed as indicated in the following example:

POLYPHENYL ETHERS

3.10 COPOLYMERS, HEAT RESISTANT POLYMERS, PLASTICS

The UDRI system of nomenclature covers copolymers under both repeating units. This is best illustrated by an example: ACRYLONITRILE-BUTADIENE COPOLYMER would be indexed and searched under ALKADIENE POLYMERS, ACRYLIC POLYMERS and NITRILE POLYMERS.

Since some heat resistant polymers which appear under a general term cannot be posted to the term HEAT RESISTANT POLYMERS, these polymers are then indexed also as HEAT RESISTANT POLYMERS. Many of the new more exotic polymers would be indexed as PHOSPHOROUS CONTAINING POLYMERS or BORON CONTAINING POLYMERS and as such could not be posted to

HEAT RESISTANT POLYMERS, since PHOSPHOROUS CONTAINING POLYMERS are not necessarily heat resistant. Heat resistance is an important property of many of these exotic polymers, and they should be indexed accordingly. Thermosetting polymers are indexed as heat resistant polymers.

The term PLASTICS is a useful term for the indexer as well as the searcher. It is posted only to the highest generic term, POLYMERS.

APPENDIX IV

INDEXING TECHNIQUES USED FOR CERAMICS, COMPOSITES, SYSTEMS, EUTECTICS AND PHYSICS

by

R. B. Smith

1. COMPOSITES

The term composites has many meanings to many people, but there is a strong movement to solidify and organize an adequate vocabulary in this area. We can only continue to use the definitions we have arbitrarly assigned to terms in this field until such time as the sciences and industries involved accept the reform. However, as new usages come into practice we will insert them into our system.

2. CERAMICS

It is expected that a complete revision of this section of the system will be needed in the near future. The terms associated with this field are being broadened to include all inorganic - nonmetallic materials. New terms should start making appearances soon which will contribute extensively to the capability of describing these materials in detail.

In the months just past most of the documents dealing with "ceramics" have been reevaluated and an attempt made to redefine terms, for our own use, that would encompass the fields of ceramic chemistry and ceramic engineering. This revision again brought out the need for new terms and new definitions which can be universally accepted by all scientific disciplines involved in the research, development, and uses of these materials.

3. SYSTEMS

3.1 FUNCTIONAL SYSTEMS

The word systems will always appear bound with a descriptor which will indicate either materials or a function such as CONTROL, GUIDANCE, or FIRE EXTINGUISHING. The use of bound terms designating functional systems is restricted to those systems which in their entirety may be component of a craft, vehicle, or facility.

3.2 MATERIALS SYSTEMS

A system of materials is defined as a combination of two or more components with variable composition. The term system often implies either a phase diagram, or a set of isotherms or isobars or both. Two component systems are called binary, three component systems are called ternary, and four component systems are called quaternary.

The nature of the components in a system will be characterized by the symbols M for metal, N for non-metal and O for metalloids. Thus a binary system consisting of two metals will be designated as M-M. A ternary system consisting of no non-metals, at least one metal and at least one metalloid will be designated by M-O etc.

Intermetallic systems are defined as systems in which all components are metals. They are indexed as M-M and the appropriate term which designates the number of components. Thus the system Zironium-Hafnium-Molybdenum will be designated as: TERNARY SYSTEMS/M-M.

The metals in the AFML/UD Information System are classified in the following 9 classes:

1. Actinides
2. Alkali Metals
3. Alkaline Earth Metals
4. Light Metals
5. P-Metals
6. Rare Earth Metals
7. Refractory Metals
8. S-Metals
9. Transition Metals

The types of the components of a system are characterized by one or more of the above classes of metals. For example a Beryllium-Aluminum System will be described as follows: BINARY SYSTEMS/M-M/LIGHT METALS. The specific system will be included in the index card in the form of a scope note.

Systems containing one or more metals and one or more non-metals and/or metalloids designated as M-N, M-O, or M-N-O will be described in the way shown in the previous paragraph, i.e. the system Magnesium-Aluminum-Silicon will be described as follows: TERNARY SYSTEMS/LIGHT METALS/ALKALINE EARTH METALS/M-O. However it is left to the discretion of the information analyst to mention the non-metal or the metalloid. In certain cases, especially when alloys, compounds or structural phases are formed, the non-metal or the metalloid should be included; for example, for the Iron-Carbon

System, the proper description will be BINARY SYSTEMS/TRANSITION METALS/M-N/CARBON. Single oxides should also be mentioned. Thus the description of the system Aluminum-Aluminum Oxide will be BINARY SYSTEMS/M-N/LIGHT METALS/SINGLE OXIDES.

Systems containing no metals, designated as N-N, N-O and O-O are described in the same general way; as binary, ternary, or quaternary systems, with one or more of the constituents included in the description.

Examples: 1) Boron-Carbon System: BINARY SYSTEMS/N-N/BORON/CARBON.
2) Hydrogen-Oxygen-Water: TERNARY SYSTEMS/N-N/GASES/WATER.
3) Beryllium Oxide-Aluminum Oxide: BINARY SYSTEMS/N-N/SINGLE OXIDES.

3.3 INTERMETALLIC PHASES

Intermetallic Phases are defined as intermediate metastable phases within an intermetallic system, with a narrow composition range, close to stoichiometric.

Intermetallic phases are described by the terms INTERMETALLIC PHASES and the appropriate base metal. Thus the intermetallic phase Ti_3Pt will be described as follows: INTERMETALLIC PHASES/TITANIUM

3.4 EUTECTICS

Metallic eutectics are named from the corresponding intermetallic phase and the term EUTECTICS, i.e. Na-K eutectic will be described as INTERMETALLIC PHASES/ALKALI METALS/EUTECTICS. In order to describe eutectics of the type M-N, N-N, M-O, N-O and O-O, the term EUTECTICS is added.

4. PHYSICS

4.1 INTRODUCTION

In physics, materials are usually a means to an end rather than the end, and therefore the materials used in physics research are frequently borrowed from other disciplines. It is not uncommon for research reports in the field of physics to ignore the materials used, or in the case of theoretical physics, to actually consider no materials. While the inclusion of such documents in a materials information system may at first seem of questionable importance to the engineer, they contain the information necessary for understanding the properties of the materials of interest to the chemist, metallurgist, and engineer.

In order to render such documents retrievable in a system designed for materials, it has become necessary to use terms that would appear to involve materials which are quite abstract as used. Thus, for example, the term cylinder, in this system, is not a material thing but a mathematical concept.

Physics reports may name the materials, and give much valuable information about them, but in many cases the main topic of the document is not concerned with the material as much as the phenomena to which the materials are incidental. For example, a document concerned with the emission of a laser might describe a doped ruby in some detail, or might just mention it in passing, because the interest is in the fact that the atoms have certain energy levels with certain transition probabilities; not that the atoms are chromium. Or, a document on plasma physics may mention that argon or hydrogen was used because of certain properties but the topic of the document may be ion current, energy transfer or propulsion.

In a multidisciplinary system it becomes necessary that certain terms have certain ambiguities. This condition negates the usefulness of one word searches. However, by proper and sufficient coordination of terms in a search, the ambiguity is overcome and documents retrieved are pertinent. A document that is purely theoretical in its concept will probably not have any useful information on materials, as such, so it frequently becomes the responsibility of the information analyst to decide if the document should be retrievable by the materials mentioned.

4.2 THEORETICAL ANALYSIS

Certain reports must be indexed using the term THEORETICAL ANALYSIS. This term should be indexed in the same link as the associated phenomenon, property, effect, apparatus, etc. being discussed. Categories of information which might logically be called theoretical analysis would be:

(1) Theoretical discussion or explanation of a physical phenomenon.
(2) Description of a physical process which entails extensive mathematical formulation; e.g., damping of vibration in elastic shells.
(3) A detailed explanation of a mathematical or theoretical basis of the operation of a type of apparatus.

4.3 DESIGN

In certain documents, pertinent information is given on the design or development of a piece of apparatus. If the design of the apparatus is of primary importance to the content of the document, the word DESIGN and the apparatus must be indexed in the same link; e.g., design information on a ruby laser would be indexed by using the terms DESIGN, LASERS and RUBIES.

4.4 APPARATUS

The rule to follow is to use general names for apparatus rather than specific; that is, use the term NUCLEAR REACTORS rather than a specific type of reactor, or TRANSISTORS rather than a specific transistor number. All electrical equipment will be indexed as general classes such as CAPACITORS, RESISTORS, CABLE TERMINALS, etc.; not by specific letter-number identifications. A convenient source for finding the list of such terms is under ELECTRONIC COMPONENTS in the thesaurus.

Transducers are indexed according to their function: (1) P-E TRANSDUCERS convert pressure or vibration to electrical energy. (2) R-E TRANSDUCERS convert radiation to electrical energy. (3) T-E TRANSDUCERS convert thermal energy to electrical energy.

Again, the only purpose for indexing apparatus is if design or development information is given, or if information is given conerning applications of extraordinary interest.

4.5 MATERIALS

Materials considered in the field of physics are indexed according to rules laid down in the sections on chemistry, metallurgy, and ceramics. However, some questions concerning the indexing of materials commonly dealt with in physical research are answered in this section.

4.5.1 SEMICONDUCTING MATERIALS

Materials such as P-Silicon and N-Germanium will be indexed as SILICON, P-TYPE and GERMANIUM, N-TYPE. Any materials which are used as doping agents for semiconductors will be indexed in the same link with the semiconductor material and the word DOPING AGENTS (material) and the word DOPING (process), if needed. Antimony selenide used to dope N-Type Germanium would be indexed using GERMANIUM, N-TYPE, DOPING, DOPING AGENTS, and ANTIMONY SELENIDE.

4.6 PROCESSES

In general if a particular process, effect, physical change etc. is of primary interest it is indexed in the same link as the material which it effects. If it is the topic of a theoretical presentation, then it should be indexed in the same link as the word THEORETICAL ANALYSIS.

4.6.1 SPECTROMETRY vs. SPECTROSCOPY

If spectrographic techniques are used as a tool for deriving physical constants of materials, the term SPECTROMETRY (use the specific type, such as INFRARED SPECTROMETRY where possible) is to be used. A theoretical development of a spectrographic technique, or any theoretical discussion of the science should be indexes as SPECTROSCOPY. Use scope notes to indicate the specific type on the index card.

4.6.2 RADIATION

All types of radiation are bound terms, such as NEUTRON RADIATION, ELECTROMAGNETIC RADIATION, etc. The word radiation should never be used by itself. The term BOMBARDMENT or IRRADIATION is used to describe the impingement of particulate radiation upon some material. For example the bombardment of semiconductors by neutrons would be indexed as: BOMBARDMENT, SEMICONDUCTORS, and NEUTRONS. It is possible that the term RADIATION DAMAGE could be used jointly with the term BOMBARDMENT since this is quite often of interest.

The term nuclear radiation refers to both electromagnetic and particulate radiation which emanate from nuclei. Nuclear radiation should be indexed by specific type (such as ALPHA RADIATION, BETA RADIATION, NEUTRON RADIATION, etc.) where possible. The term NUCLEAR RADIATION would be used only where no specific radiation is mentioned, as theoretical report on nuclear radiation.

4.6.3 NUCLEAR REACTIONS

Nuclear reactions refer to the transformation of a specific nucleus into one or more different nuclei by any of a number of processes, e.g., fission, fusion etc. If the specific process is known, it should be indexed (NUCLEAR FISSION, NUCLEAR FUSION, etc.). If no specific reactions are given, the term NUCLEAR REACTIONS may be used. Nuclear reactions will be indexed in the same link as the isotop which is undergoing the change. Isotopes of the elements should be indexed by writing the name of the element, followed by the mass number of the isotope, i.e., CARBON 14, IRON 57, etc. Nucleon-Nucleon interactions may be indexed as NUCLEAR PARTICLE INTERACTIONS. Some of the more prevalent specific types are posted on this term.

4.7 PROPERTIES

In this system properties refer to properties of materials. The term properties is never used by itself, but rather in bound terms such as PHYSICAL PROPERTIES or SEMICONDUCTOR PROPERTIES. In indexing it is important to remember that the materials and/or apparatus of primary importance must be indexed in the same link as any properties or processes which affect them.